METAL PROGRESS

SEPTEMBER 1950

THIS ISSUE

Complete Table of Contents on p. 313

An Invitation to You . . .

IN OUR present war and with the serious threat of an even more widespread conflict, high production is the principal contribution that our strategic metallurgical industries can make to the defense of our country. You know that this high production can be obtained only by taking full advantage of new materials, new equipment and new methods.

From past experience, you are well aware that the National Metal Congress and Exposition provides the best way to be sure that you are completely informed on all these new developments. This year, this event, the 32nd, will be held in Chicago from October 23rd to 27th.

You are busy. So are all those who are participating by presenting their products and their technical knowledge at this congress and exposition. Only you, through your experience, can fully understand how this information can be used to best advantage to make higher production possible for your product.

The officers of A.S.M. urge you to decide now to be with us in Chicago.

ARTHUR E. FOCKE
President, A.S.M.

P.S.: Bill Eisenman reports that although most of the hotel rooms originally reserved for us have been assigned, Chicago is unusually well supplied with first-class hotels and it has been arranged to provide an additional number of rooms. For reservations, please write to Chicago Convention Bureau, 33 N. LaSalle St., Chicago 2, Ill.

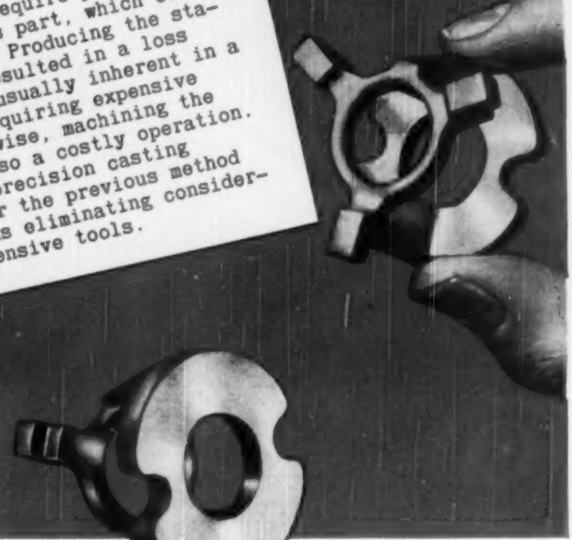
MICROCASTINGS

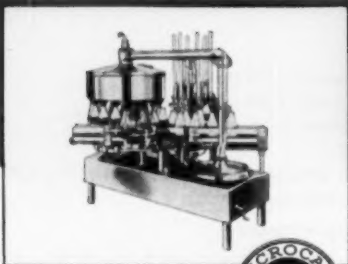
Cut Cost 60%

ELIMINATE POROSITY • MACHINING

Part Name: Stabilizer
Utilization: Milk Bottling Equipment
Alloy: 302 Stainless Steel

Health Department Standards require porosity-free stainless steel for this part, which comes in direct contact with milk. Producing the stabilizer from sand casting resulted in a loss from porosity, a condition usually inherent in a casting of this size and requiring expensive machining to correct. Likewise, machining the part from bar stock was also a costly operation. The Microcast Process of precision casting effected a 60% saving over the previous method of manufacture, as well as eliminating considerable waste stock and expensive tools.





MICROCAST T. M. REG. U. S. PAT. OFF.

MICROCAST PRECISION CASTINGS PROCESS

MICROCAST components, as cast, are structurally sound, dimensionally uniform, and cast to such close tolerances that little or no machining is needed. Intricate shapes such as this can be specified in such extremely hard, non-machineable, non-forgeable alloys as stainless steel, tool steel, Stellite, and others. Write for complete technical information.

WRITE FOR FREE MICROCAST MANUAL

The Microcast Process is graphically described in this 16-page booklet. Many applications are shown, together with specifications and step-by-step explanation. Write today!

MICROCAST

MICROCAST DIVISION
AUSTENAL LABORATORIES, INC.
224 East 39th Street • New York 16, New York
715 East 69th Place • Chicago 37, Illinois

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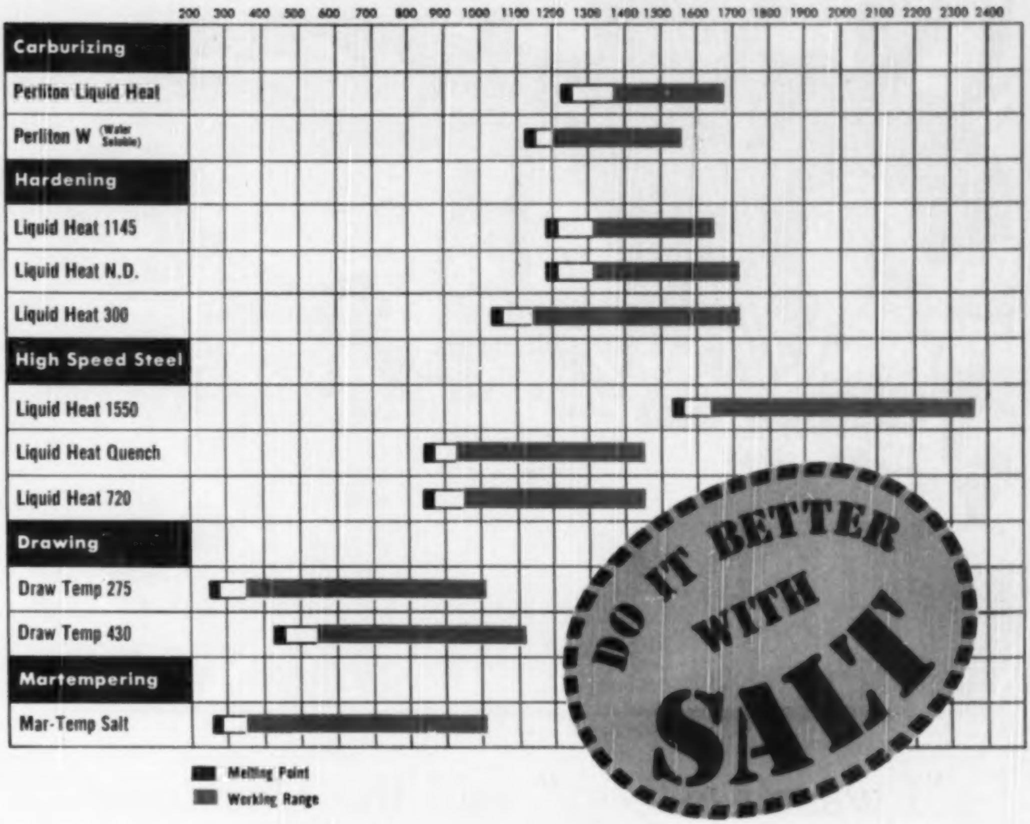

200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400
Carburizing
Perliton Liquid Heat
Perliton W (Water Soluble)
Hardening
Liquid Heat 1145
Liquid Heat N.D.
Liquid Heat 300
High Speed Steel
Liquid Heat 1550
Liquid Heat Quench
Liquid Heat 720
Drawing
Draw Temp 275
Draw Temp 430
Martempering
Mar-Temp Salt
DO IT BETTER WITH SALT
Melting Point
Working Range

"I wasn't asleep," said the Dormouse

EVERY boy and girl knows the drowsy Dormouse of Alice in Wonderland. He was elbowed and pinched by the Mad Hatter and the March Hare as he mumbled in his sleep at the tea party.

But our young people aren't so well versed in everyday economics. They have a sadly distorted picture of the profits of business. They don't realize why profits are necessary, how small they are, or how they are divided.

For instance, in a recent survey of high school seniors, it was discovered that they believe over 50% of the sales dollar is profit and they think stockholders receive 24% of it. Actually business profit averages less than 8%, with less than 3% distributed as dividends. Business uses most of its profit, moderate as it is, for new plant and equipment, to improve products and to make more jobs.

Misconceptions among our youth bode ill for America's future. They open the door for too ready acceptance of dangerous isms and false foreign philosophies. Such misunderstanding of economics can be corrected only with facts supplied by business itself. You as a leader in your community must share this responsibility.

The American business man must not allow himself to be cast in the role of the Dormouse, pinched and pilloried by the March Hares of communism and the Mad Hatters of the "everything for nothing" state.

THE YOUNGSTOWN SHEET & TUBE CO. 1900 YOUNGSTOWN 1950 50 YEARS OF SERVICE

The Youngstown Sheet and Tube Company

General Offices--Youngstown 1, Ohio
Export Offices--500 Fifth Avenue, New York
MANUFACTURERS OF CARBON, ALLOY AND YOLOY STEELS

ELECTROLYTIC TIN PLATE - COKE TIN PLATE - WIRE - COLD FINISHED CARBON AND ALLOY BARS - PIPE AND TUBULAR PRODUCTS - CONDUIT - RODS - SHEETS - PLATES - BARS - RAILROAD TRACK SPIKES.

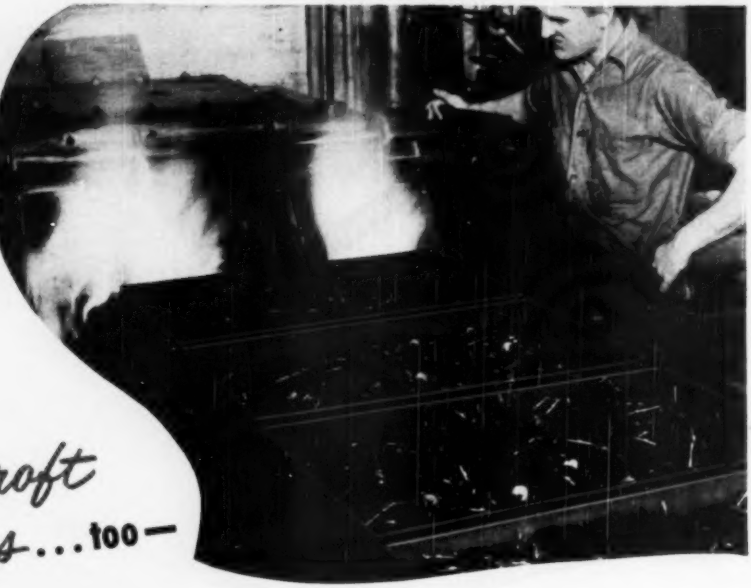
SEVEN STRONG REASONS

A better steel for the purpose in hand has always found favor with manufacturers of commercial vehicles . . . currently the trend is to N-A-X HIGH-TENSILE steel.

GREAT LAKES STEEL CORPORATION

N-A-X Alloy Division, Ecorse, Detroit 29, Michigan

NATIONAL STEEL CORPORATION



Inconel trays discharging from a 15-foot Holcroft carbo-nitriding furnace. The trays measure 15 in. by 26 in.

In *Holcroft Furnaces* . . . too—

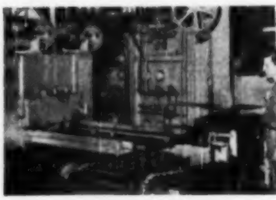
It's INCONEL for longer-lasting trays

Like other leading makers of heat-treating equipment, Holcroft & Company prefer Inconel® for furnace parts and fixtures.

In comparative tests, Holcroft & Company found that furnace baskets and trays made of Inconel lasted longer, were lighter in weight, and required less maintenance than those made of other metals.

That is why Holcroft & Company have, for years, considered Inconel a superior metal for baskets and trays used in carbo-nitriding.

Inconel—and Inconel alone—brings the heat-treating equipment designer this outstanding *combination* of desirable properties:



Entrance of a 15-foot Holcroft carbo-nitriding furnace. Because of its excellent thermal durability and high corrosion-resistance, Inconel was chosen for the furnace trays.

1. Ability to withstand service temperatures up to 2200°F.

2. High resistance to all sulfur-free heat treating atmospheres.

3. High creep and stress-to-rupture properties at high temperatures.

4. Good resistance to scaling and embrittlement.

5. Workability and weldability. Welds in Inconel have characteristics identical with those of the parent alloy itself.

Next time you consider new furnace equipment, remember that Inconel is your promise of long-time economy when the heat is high!

For further information about Holcroft heat-treating equipment, write directly to Holcroft & Company, 6545 Epworth Blvd., Detroit 10, Mich.

Remember, too, that Inco's Technical Service Department is always ready to help you solve high-temperature and corrosion problems.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

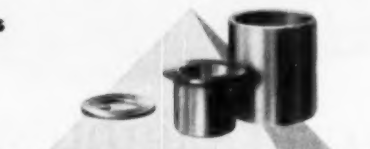
EMBLEM OF SERVICE INCO

INCONEL . . . for long life at high temperatures

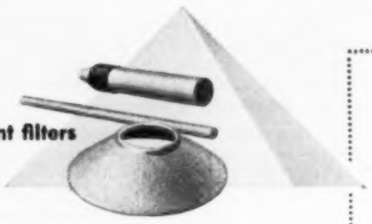
Customers state... **Oilite**

Products *yield pyramidal savings...*

1. Finished machine parts



2. Heavy-duty oil-cushioned, self-lubricating bearings



3. Permanent filters

4. Heavy-duty oil-cushioned, self-lubricating cored and bar stock

5. Friction units

Contact your local Oilite field engineer or the home office

SAVINGS in

- Unit Cost
- Assembly Cost
- Capital Investment
- Burden • Floor Space

PLUS

- Quality and Service
- Engineering Insurance

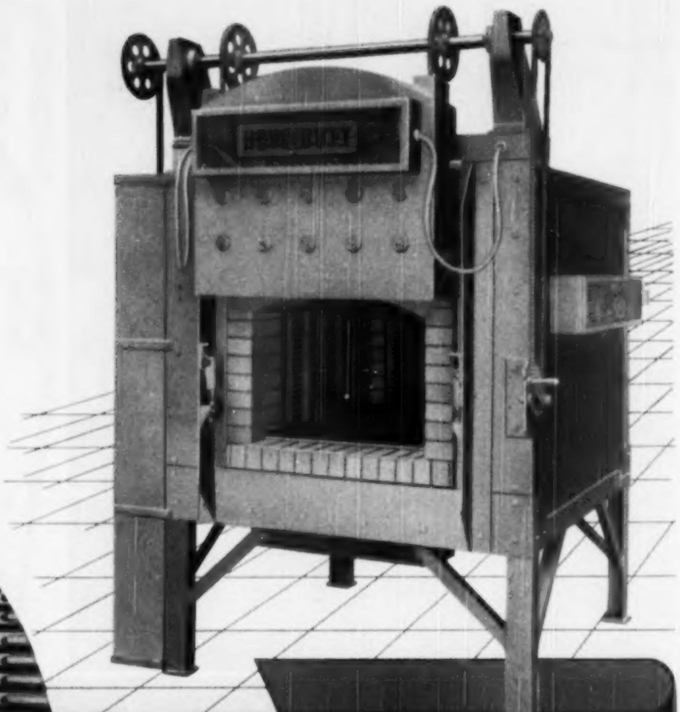
PLUS

(Nationwide and Canada)

- Field Engineers
- Distributors • Dealers
- Bearing Depots

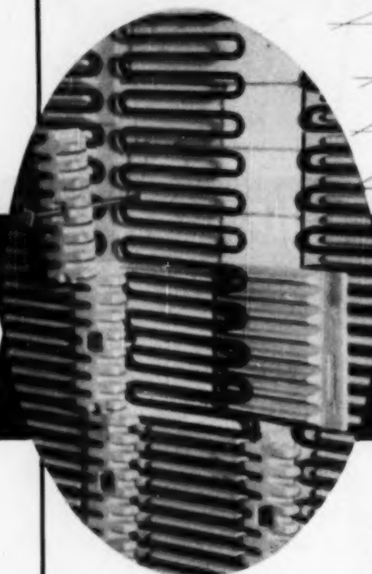
Amplex MANUFACTURING COMPANY

SUBSIDIARY OF CHRYSLER CORPORATION
DETROIT 31, MICHIGAN



ADEQUATE HEATING ELEMENT SUPPORT

Radiant plates made of high grade refractories fully support the heating elements.



It's the RELIABILITY of HEVI DUTY Furnaces *. . . that* COUNTS

ADVANCED design, rugged construction and high quality materials are combined with years of furnace building experience to produce Hevi Duty box furnaces. Round rod heating elements and sturdy radiant plate element supports assure continuous performance under severe operating conditions. Users report that reliability and trouble free service are outstanding advantages of Hevi Duty furnaces.

LONG HEATING ELEMENT LIFE

Round rod return-bend heating elements have less surface area to oxidize or deteriorate at elevated temperatures.

WRITE FOR HEVI DUTY BULLETIN NO. HD441

HEVI DUTY ELECTRIC COMPANY

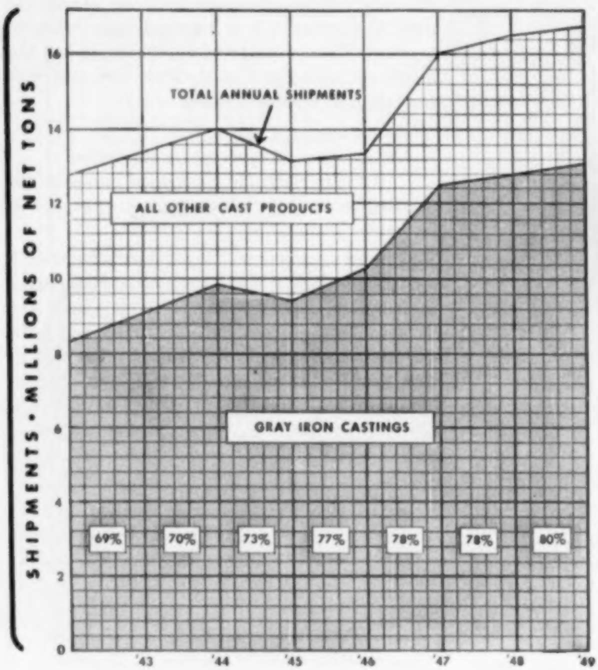
HEAT TREATING FURNACES HEVI DUTY **ELECTRIC EXCLUSIVELY**

DRY TYPE TRANSFORMERS — CONSTANT CURRENT REGULATORS

MILWAUKEE 1, WISCONSIN

AGAIN!...

GRAY IRON LEADS THE FIELD



In 1949
GRAY IRON accounted for
80%
of all cast metal products shipped

Note the steady increase in annual shipments of Gray Iron Castings as shown on chart at the left. Gray Iron's percentage of total cast metal products has increased from 69% in 1943 to about 80% in 1949.

Here's factual proof of Gray Iron's constantly increasing acceptance by design engineers, production and purchasing executives throughout industry. The reasons? They're summed up in Gray Iron's unmatched combination of characteristics, including . . . *castability, rigidity, low notch sensitivity . . . resistance to wear, heat and corrosion . . . machinability, vibration absorption, durability and wide strength range.*

Are you making full use of these advantageous characteristics in *your* products?

Make It Better with Gray Iron

Second largest industry in the Metal-working field

GRAY IRON FOUNDERS' SOCIETY, INC.

NATIONAL CITY-E. 6th BLDG., CLEVELAND 14, OHIO

Bulletin on SUPER REFRACTORIES by CARBORUNDUM

TRADE MARK

NO. 10 SEPTEMBER, 1950

How Can Super Refractories Justify Their Higher Initial Cost?

In adjudging the value of a super refractory for a particular job, price should not be the sole determining factor. *Their overall usefulness and the savings they can effect should be the measure of their worth.* Refractory cost per unit handled is a good yardstick.

With their exceptional resistance to furnace atmospheres, thermal shock, slags, cracking, mechanical wear and high temperatures, super refractories by CARBORUNDUM give exceptionally long service. They also extend the life of adjacent refractories, eliminate frequent furnace outages, increase production, and decrease replacements and labor costs.

Another unique property of certain super refractories that often justifies higher initial cost, is high thermal conductivity. This provides quicker, more uniform heat delivery to the charge. Material quality is bettered, fuel consumption reduced, rejects cut, and output improved.

Still other benefits are to be gained in certain other types of installations. These applications, too, are usually limited to areas which cause repeated costly repairs and shut-downs.

Super refractories by CARBORUNDUM are most often applied where other refractories, for any of many reasons, are incapable of doing an adequate job.

Physical Properties of Super Refractories by CARBORUNDUM
Trade Mark

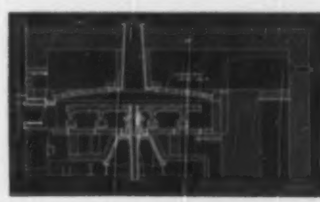
	CARBOFRAX Silicon Carbide	MULLFRAX Electric Furnace Mullite	MULLFRAX S Converted Kyanite	ALFRAX K	ALFRAX B	ALFRAX BI
				Electrically Fused Alumina		
Heat Conductivity at 2200° F. in BTU/hr. sq. ft. and °F. /in. of thickness	109 BTU	16 BTU	9 BTU	24 BTU	12 BTU	7 BTU
REFRACTORINESS PCE CONE	37-40	38-39	37-38	37-39	39-40	38-39
SPALLING RESISTANCE	High	High	High	Good	Good	Good
ABRASION RESISTANCE	High	Medium	Medium	High	Medium	Low
THERMAL EXPANSION (25° — 1400° C.)	.0000044	.0000059	.0000069	.0000074	.0000086	.0000086
MODULUS OF RUPTURE @ 2460° F. PSI	880-3125	100-250	175-475	100-1050	100-225	50-100
WEIGHT 9 IN. STRAIGHT	9.25 lbs.	9 lbs.	8 lbs.	10.1 lbs.	7.25 lbs.	4.8 lbs.

Here's How Super Refractory Skids Justified their Cost

Since the metal skid rails in this furnace were replaced with CARBOFRAX silicon carbide rails, output has increased and maintenance dropped. This furnace is used for heating and reforming splice bars at about 2300° F. The 2½" round, low carbon steel skids required complete replacement every six weeks. Two full working days were lost — shutdowns were costly. And even between replacements, the metal skids warped badly and required straightening.

Now, however, long uninterrupted production has been achieved. The CARBOFRAX skids have been in operation for *over 2 years* — and have required *no attention.* And as much as 35.4 tons of bars have been pushed through the furnace in seven hours.

The same unique properties of these CARBOFRAX skids have also made possible similar improvements in other reheating furnaces.



Super Refractory Doubles Furnace Output

When the fireclay dome in this Mannhiem type muriatic acid furnace was replaced by a CARBOFRAX silicon carbide arch *output was doubled.* What's more, this changeover cut the fuel input ratio by 50%.

In terms of initial furnace investment, this means that two furnaces equipped with CARBOFRAX arches *will out-produce four identical furnaces*

"Carborundum," "Carbofrax," "Mullfrax," "Silfrax," "Alfrax" are registered trademarks which indicate manufacture by The Carborundum Company

Address all correspondence to: Dept. C-90, THE CARBORUNDUM COMPANY, Refractories Division, Perth Amboy, New Jersey

Continued on other side →

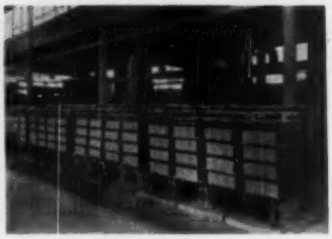
← Continued from other side
having fireclay arches. The savings in maintenance, labor and fuel costs are obvious.

One of the unique properties of CARBOFRAX shapes making this possible is a thermal conductivity 11 to 12 times that of fireclay (nearly equivalent to that of alloy steel at high temperatures). Another characteristic is the high hot strength of CARBOFRAX brick and shapes. At 1350° C, for example, the modulus of rupture is well over 3000 psi. Furthermore, shrinkage is practically non-existant. Measured cold after 1¾ hours at 1500° C, actual tests show zero linear contraction. As a result, serious distortion — even with spans of 20 feet or more — is avoided, and dome life is much improved.

Maintenance Savings Pay for These Brick

Pictured here is the front wall of a 150,000 lb. per hr. pulverized coal fired boiler. The photo was taken three years after the CARBOFRAX silicon carbide burner rings had been installed and following the annual pointing-up and cement wash coating of the inner faces. None of the brick had been reset. The CARBOFRAX rings have resisted the abrasive action of the fuel as well as the spalling condition promoted by the secondary air around the burners. Considerable additional service is expected from these brick.

CARBOFRAX brick have been used to face the front wall above and around these burner rings. Previously, slag fingers built up on this wall, extended down over the burners and distorted the flame. As a result, it was necessary to shut down each month to bar off the slag. Now, however, slag fingers do not build up on the hard, dense face of the CARBOFRAX wall and these monthly shutdowns have been eliminated. Consequently, the operator considers that labor and maintenance savings alone have paid for the brick.



Tile Manufacturer Increases Car Capacity 40%

By changing from clay saggers to open settings with CARBOFRAX silicon carbide setter tile, I-beam posts and saggers, this floor and wall tile manufacturer increased car capacity approximately 40% — with no change of kiln schedule.

In this operation, bisque wall tile are fired on CARBOFRAX tile. The setter slabs and ware are carried on 3-point support of I-beam posts. Floor tile are burned in CARBOFRAX saggers on top of the car. And after each trip, the cars are torn down and rebuilt.

The high mechanical strength, freedom from warping and blistering, and resistance to thermal shock of CARBOFRAX kiln furniture, have resulted in important savings to this company. Super refractories by CARBORUNDUM and engineered car settings have made the difference — as has been the case in many other ceramic plants.

Super Refractory Proves Profitable for Incinerator Operation

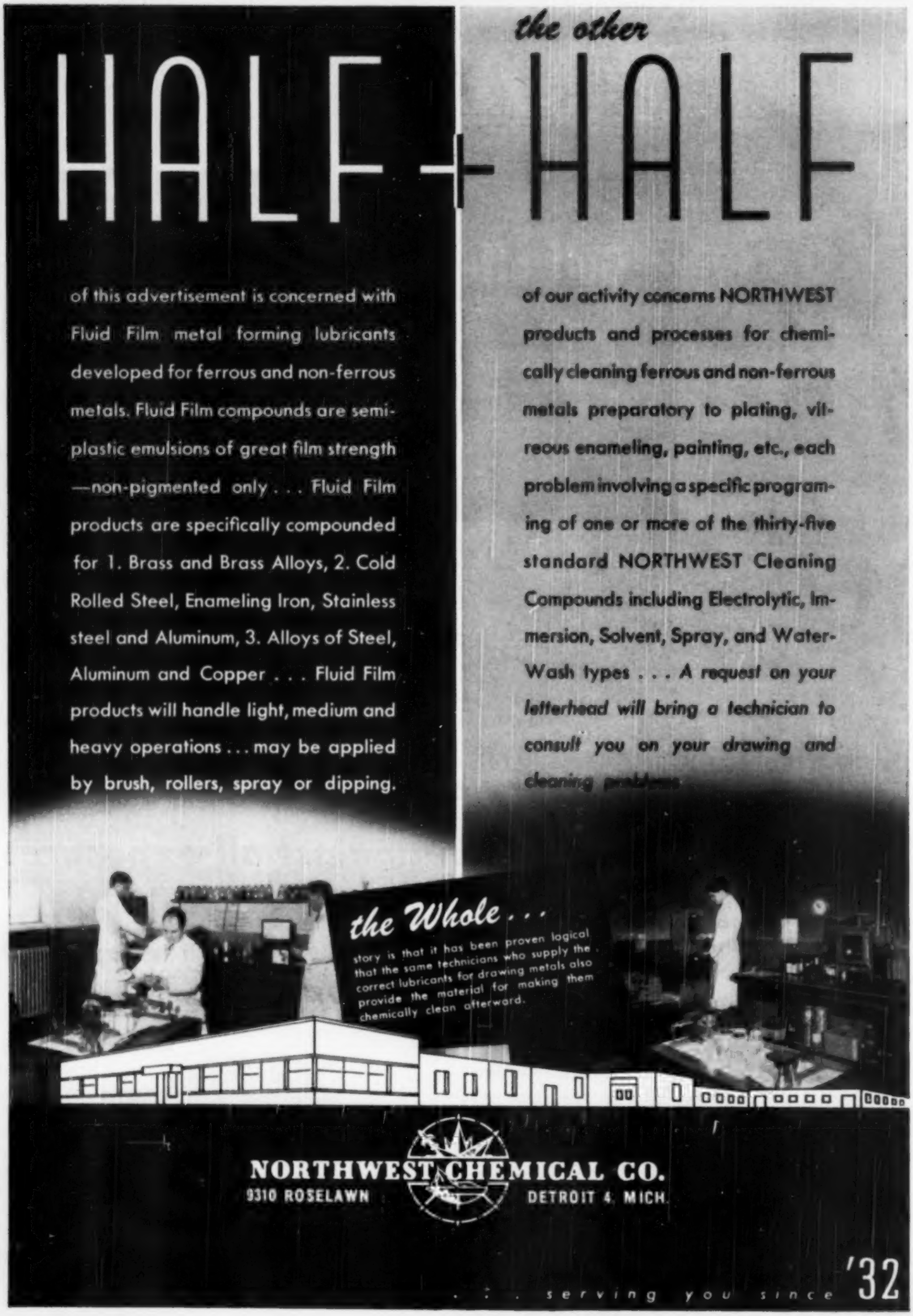
This photo shows part of the interior of an incinerator operated by a large industrial city. The furnace is approximately 8' x 24', and operates at 1700° — 2400° F. CARBOFRAX silicon carbide brick are used from the grate level to the tubes, and CARBOFRAX shapes are used around the four stoking door openings.

Note the excellent condition of the CARBOFRAX brick after more than three years service. Note, also, the absence of fly ash and other accumulations despite the fact that these walls had not been cleaned for 1½ years. Compare this with the deposit above the tubes where other refractories are used. The difference is particularly pleasing to the operator because, with fireclay, brickwork was always pulled away in the process of removing these accumulations. Moreover, CARBOFRAX brick are very resistant to erosion and cutting back — an added problem when other types of linings were used.

Before the installation of CARBOFRAX brick, this incinerator needed complete rebuilding every two years, plus patching and replacements during this period. Now, however, periodic repairs have been eliminated, and even after three years CARBOFRAX brick still are satisfactory for considerably more service.

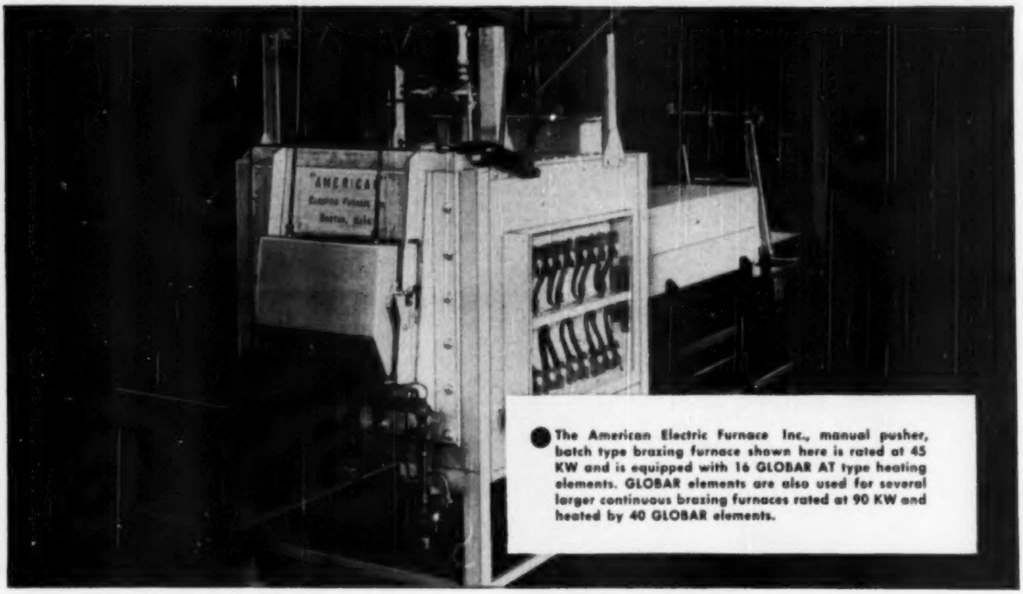
The high refractoriness, cracking and spalling resistance, and excellent hot strength of CARBOFRAX brick have been used advantageously in this job. Other product properties of special value around the stoking doors are resistance to thermal shock and mechanical abrasion.

This is another example of how the benefits of super refractories by CARBORUNDUM more than justify their original cost.


HALF + the other HALF
of this advertisement is concerned with Fluid Film metal forming lubricants developed for ferrous and non-ferrous metals. Fluid Film compounds are semi-plastic emulsions of great film strength —non-pigmented only . . . Fluid Film products are specifically compounded for 1. Brass and Brass Alloys, 2. Cold Rolled Steel, Enameling Iron, Stainless steel and Aluminum, 3. Alloys of Steel, Aluminum and Copper . . . Fluid Film products will handle light, medium and heavy operations . . . may be applied by brush, rollers, spray or dipping.
of our activity concerns NORTHWEST products and processes for chemically cleaning ferrous and non-ferrous metals preparatory to plating, vitreous enameling, painting, etc., each problem involving a specific programing of one or more of the thirty-five standard NORTHWEST Cleaning Compounds including Electrolytic, Immersion, Solvent, Spray, and Water-Wash types . . . A request on your letterhead will bring a technician to consult you on your drawing and cleaning problems.
the Whole . . .
story is that it has been proven logical that the same technicians who supply the correct lubricants for drawing metals also provide the material for making them chemically clean afterward.
NORTHWEST CHEMICAL CO.
9310 ROSELAWN
DETROIT 4, MICH.
. . . serving you since '32


REEL FACTS
PRODUCT: Fishing Reel
MATERIAL REQUIREMENTS: High Corrosion-Resistance; Precision Machining Characteristics
MATERIAL USED: Republic ENDURO Stainless Steel, Type 303 Free Machining Analysis (other ENDURO Analyses used for stampings and gears).
RESULTS: Very Good. No difficulty encountered in machining intricate parts shown below.

American Electric Furnace Inc. selects GLOBAR Heating Elements



The American Electric Furnace Inc., manual pusher, batch type brazing furnace shown here is rated at 45 KW and is equipped with 16 GLOBAR AT type heating elements. GLOBAR elements are also used for several larger continuous brazing furnaces rated at 90 KW and heated by 40 GLOBAR elements.

LIBERAL SAFETY FACTOR

GLOBAR silicon carbide elements operate safely at temperatures well above normal employed in brazing furnaces.

MORE KILOWATTS INPUT

High production rates are obtainable through greater KW input per ft. of heating chamber.

NO FURNACE SHUTDOWN

Elements are operated in groups which may be replaced while furnace is operating.

CONVENIENT ELEMENT REPLACEMENT

All terminal connections of GLOBAR rod type elements are external for simple and fast installation.

GLOBAR non-metallic heating elements offer many advantages in addition to those listed for this specific application. Detailed information is available. Write Dept. X-90, The Carborundum Company, GLOBAR Division, Niagara Falls, New York.

GLOBAR Heating Elements BY CARBORUNDUM

TRADE MARK

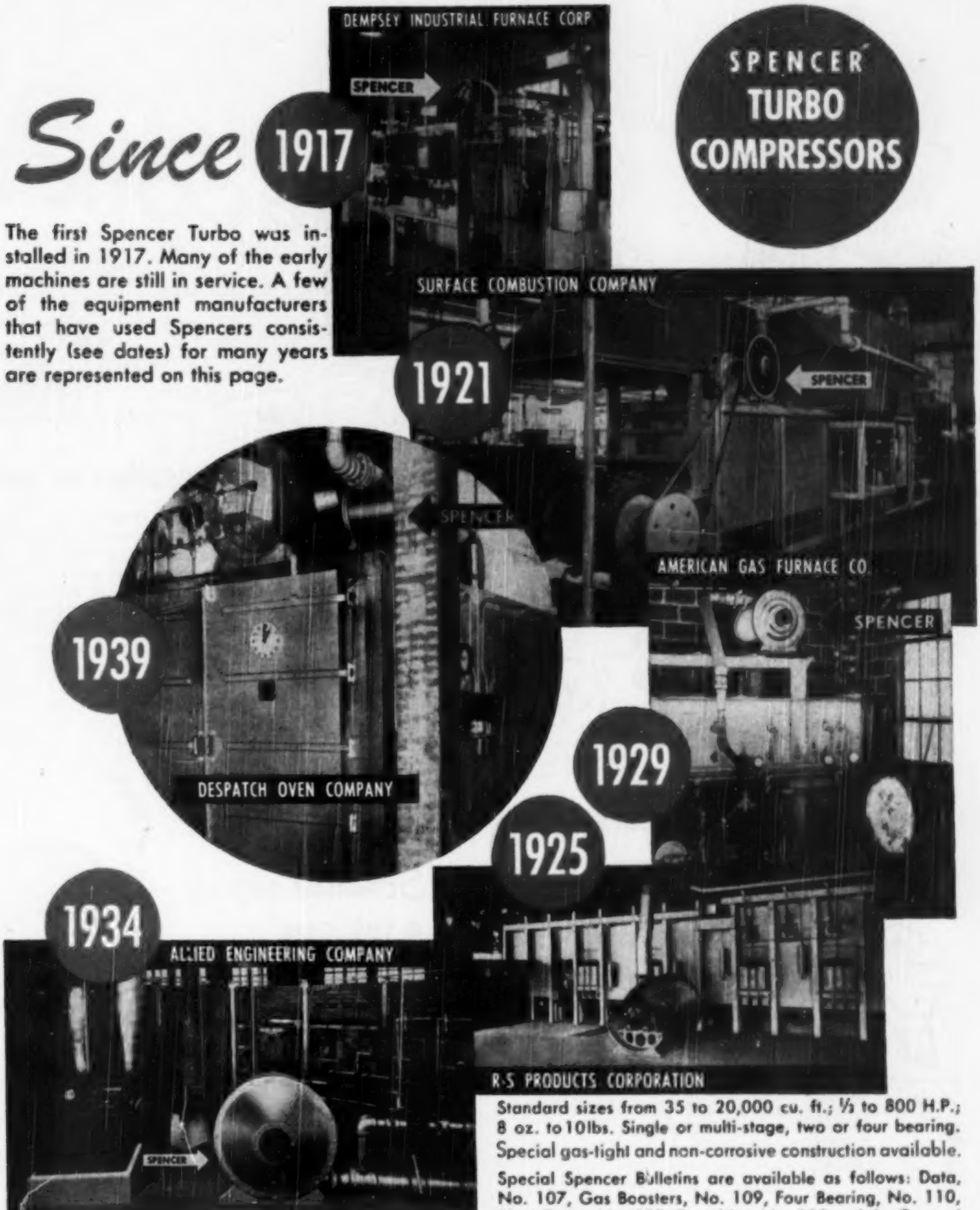
CARBORUNDUM

"Carborundum" and "Globar" are registered trademarks which indicate manufacture by The Carborundum Company

Since 1917

SPENCER TURBO COMPRESSORS

The first Spencer Turbo was installed in 1917. Many of the early machines are still in service. A few of the equipment manufacturers that have used Spencers consistently (see dates) for many years are represented on this page.



Standard sizes from 35 to 20,000 cu. ft.; ⅓ to 800 H.P.; 8 oz. to 10lbs. Single or multi-stage, two or four bearing. Special gas-tight and non-corrosive construction available.

Special Spencer Bulletins are available as follows: Data, No. 107, Gas Boosters, No. 109, Four Bearing, No. 110, Blast Gates, No. 122. Foundries, No. 112 and the General Bulletin is No. 126. 359-F

THE SPENCER TURBINE COMPANY • HARTFORD 6, CONNECTICUT

SPENCER
HARTFORD

Land of the free!

. . . where enduring copper is a symbol of our better way of life . . . where copper and its alloys provide a myriad of useful, low-cost, mass-produced conveniences. Take this Jarco Key-Chain Flashlight: Solid brass deep-drawn shell and cap; solid brass screw-machined, threaded and knurled nut; solid brass bead chain; battery, tension spring and focused bulb. Made by Jarco Metal Products Corporation, New York. Sold by the millions at 39¢ retail.

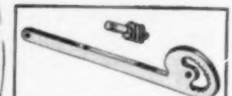
Twenty years—

That's not a sentence. It's a guarantee that goes with every automatic water heater sold by Bauer and Company of Hartford, Conn. One big reason why is that Everdur*, carbon-arc welded, is used for the non-rust tank. Coincidentally, twenty years ago the Bauer Company discovered the merits of this Copper-Silicon Alloy—strength, corrosion resistance, workability and weldability—and has been using it ever since for tanks ranging from 2½ to 150 gallons. Dependable stuff, that Everdur.

*REG. U.S. PAT. OFF.

P.S. If you are having difficulty in selecting a metal for a particular application, let us help you with it. Talking about it entails no obligation—and our vast experience places us in a position to come up with the right answer. Address The American Brass Company, Waterbury 20, Conn.

Anaconda

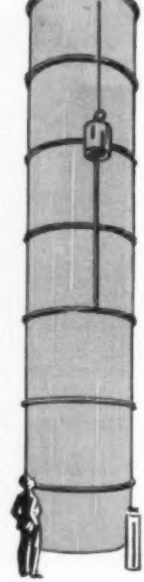


It works—weather or not

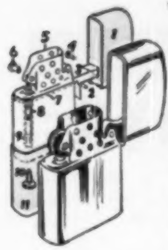
When the H. S. Getty Company, Inc., Philadelphia, designed its "Internal Gear Construction Window Operator," many difficulties presented themselves. First, it had to be non-rusting, corrosion resistant and yet moderate in cost. Regular brass alloys answered that. But—some parts, such as the operating arm and machine-cut worm, needed extra strength and stamina to resist the stresses caused by rain-swollen or iced-up sash. Everdur, The American Brass Company's Copper-Silicon Alloys answered *that* . . . proving what we've been saying right along—that there's an Anaconda Copper Alloy available to do 'most *any* kind of job. And economically, too!

Schenley sets up a tall one

Ever wonder why copper has been used so long—and so diversely—in breweries and distilleries? The question is prompted by this three-story still, one of the many pieces of equipment made of copper in the new Canadian Schenley Limited distillery at Valleyfield, Quebec. The answer: Copper is readily worked into the unusual shapes and forms required; it provides high corrosion resistance, and never rusts to contaminate products; it's tops in rapid heat transfer; it can be readily and dependably joined by soldering, brazing, oxyacetylene welding, or by the newer carbon arc, inert-gas-shielded welding method. Most of the equipment for the Schenley plant was fabricated in Canada by Canadian-Vickers Limited of Montreal—of Anaconda Copper, of course.



Metals at work



"No Zippo owner ever spent a cent for repairs"

That is the unqualified, unconditional guarantee held by millions of Zippo Lighter owners. How does Zippo do it? First, the design is excellent. Second, meticulous care is employed in manufacturing. And third, the right metals are used in the right places . . . metals that are easy to fabricate, economical to finish and that do their assigned jobs for years on end. You guessed it. Eleven components of the Zippo Lighter are made of Anaconda Brass and Nickel Silver Alloys in the form of strip, wire, rods and tubes.

We take our own medicine

And it's good! For years we've been extolling the merits of welding with Bronze. Then our subsidiary, the American Metal Hose Branch ran into a toughie—braze-welding the fittings on these 2½" diameter Vibration Eliminators for refrigeration lines. The assembly includes a thin-wall flexible bronze tube, a rigid copper tube fitting, a copper ferrule, and—672 strands of .028" bronze wire. Result: a strong, ductile, vibration-resistant weld, absolutely leakproof against the most searching refrigerants. Want a booklet on Anaconda Bronze Welding Rods? Ask for Publication B-13.

Stuffed with Copper

Ever since The American Brass Company developed a means of producing electrolytically deposited copper in practically unlimited lengths, new uses for this paper-thin metal pop up continuously. Most recent is the application of "Electro-Sheet" in Multi-Velocity Air Filters, made by Research Products Corp., Madison, Wis. The copper, slit and expanded, has important advantages over other materials: Light weight, high dirt-holding capacity, non-clogging and improved cleanability features; and lower restriction at all air velocities up to 550 feet per minute. Just in case you want to know, "Electro-Sheet" is available in thicknesses from .00068" to .0094", in widths up to 62".

Look this way, please

Designed to sell at $14.95, the Beacon "225" Camera, produced by Whitehouse Products, Inc. of Brooklyn, N. Y., introduces a degree of precision befitting much more costly cameras. Handsomely styled, the Beacon "225" uses standard film and is inexpensive to operate. This policy of offering high-quality at low-cost has met with marked success, for more than 300,000 Beacon Cameras have been sold to date. Dozens of the intricately formed camera parts, made of copper base alloys, were produced by our Waterbury Brass Goods Branch—in large quantities, inexpensively, to unusually close tolerances in multiple die production. If you're interested in this type of work your sample, sketch or description will start the ball rolling.

Out of sight but not out of mind

Maybe you never gave a thought to those gas service lines that run from the main into the house. But you can bet your gas company does, for replacing rusted out steel services is a major item of maintenance expense. So . . . twelve years ago a large midwest utility started replacing gas service lines with copper tube—very often eliminating trenching by pulling the smaller 1" or 1¼" tube through the reamed-out steel pipeline. 25,000 replacements have been made by this one company alone, and—surprise—the total cost of a rust-free copper renewal is considerably less than that of a steel replacement!

ANACONDA

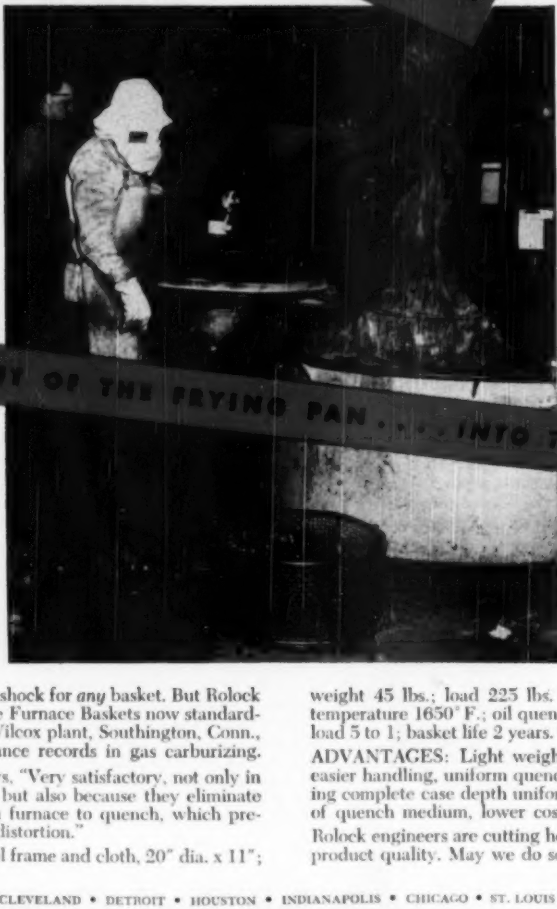
the name to remember in

COPPER, BRASS & BRONZE

ROLOCK

HEAT AND CORROSION RESISTANT

FABRICATED ALLOYS



Visit us at Booth No. 522, Metal Show, Chicago, week of October 23rd.

Photograph shows fire-flash at instant basket and load contacted the quench.

. . . just about the toughest shock for *any* basket. But Rolock fabricated-welded Pit Type Furnace Baskets now standardized at the Peck, Stow & Wilcox plant, Southington, Conn., are showing fine performance records in gas carburizing.

Their department head says, "Very satisfactory, not only in view of severe conditions, but also because they eliminate rough work handling from furnace to quench, which previously caused excessive distortion."

DETAILS: Baskets Inconel frame and cloth, 20" dia. x 11"; weight 45 lbs.; load 225 lbs. (hand tool parts); furnace temperature 1650° F.; oil quench (100° F.); ratio live-dead load 5 to 1; basket life 2 years. Furnace load 3 baskets.

ADVANTAGES: Light weight, greater furnace capacity, easier handling, uniform quench (wire cloth sides) providing complete case depth uniformity, minimum dragout loss of quench medium, lower costs.

Rolock engineers are cutting heat-hour costs and improving product quality. May we do so for you? Write for catalog.

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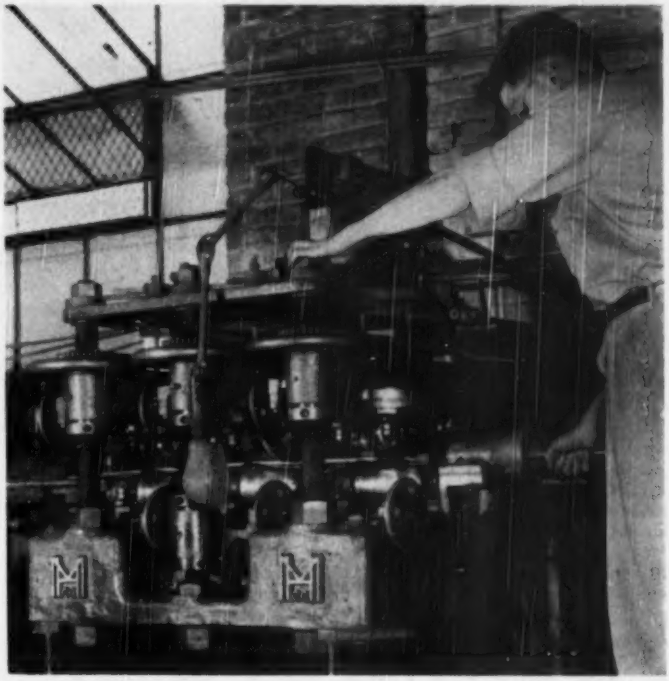
Easier Operation, Lower Cost

6-RL-50

ENGINEERING DIGEST OF NEW PRODUCTS



STRAIGHTENING MACHINE: Straightening stainless steel, nickel and nickel-alloy seamless tubing to achieve a tolerance of 0.020 in. per ft. is accomplished by this rotary straightener. Tubing ranging in size from 1½ in. down to ¼ in. comes to this Mackintosh-Hemphill Co. machine after drawing, bright or open air annealing, and pickling. The last draw to specified size causes each length of nonferrous tube to take a "set" or a "bow". Deformation of the tubing back to perfect straightness is essential in order to meet rigid specifications of tubing fabricators.

The rotary straightener assures roundness and an unmarked surface of tubing passed between its six guideless crossed rolls. This is somewhat of an unusual achievement since tubing walls are as thin as 0.010 in. on 1¼ in. O.D. tube, 0.003 on ¼ and 3/16 in. tube, and 0.005 on ½ in. O.D. nonferrous tubing.

For further information circle No. 689 on literature request card on p. 296B

GRAPHITE FLUXING TUBES: "National" Graphite Fluxing Tubes are used for the introduction of gases such as nitrogen, chlorine, argon and helium into molten nonferrous metals to reduce hydrogen, oxides and inclusions. This "degassing" operation, which is performed either in the furnace or in the ladle as close to the time of pouring as possible, has been used extensively with aluminum and aluminum base alloys.

"National" Graphite tubes do not dissolve in aluminum, magnesium, brasses and most other nonferrous baths, and will not contaminate the metal; neither will metal and dross adhere tightly to them. Cleaning costs, compared to those of metal pipe or tubes, are therefore considerably reduced. The tubes also will withstand the high temperatures of the molten metal better than other practical materials of construction.

The tubes are made in three general types, A, B and C, the selection of which is determined by the requirements of the particular job. They are made in 1½ and 2-in. diameter sizes, in lengths from 24 to 108 in.

A complete description of Graphite Fluxing Tubes, as well as engineering drawings and specifications, methods of adapting to iron pipe fittings, and ordering information is contained in a new *Catalog Section M-8709*. National Carbon Division, Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, New York.

For further information circle No. 690 on literature request card on p. 296B

HARD COATING FOR ALUMINUM: A new hard coating for aluminum, which makes this light metal eligible for the first time in many applications heretofore monopolized by steel alloys, has been developed in the engineering laboratories of Glenn L. Martin Co.

The new Martin hard coating for aluminum, designated as "MHC" finish, opens a way for the industry to take fuller advantage of the lightweight attribute of this metal in aircraft manufacture, it having been necessary—until now—to resort to other metals for all structures requiring high wear-resistance. Standard tests performed on a Taber Abrasion Tester have shown the new coating to possess a remarkable resistance. After 50,000 cycles, for example, it evidenced only half as much wear as did cyanide case hardened steel.

Though laboratory development of the process has been under way for over two years, as a result of certain basic work accomplished by Charles F. Burrows, Martin research metallurgist, the full range of MHC's practical application has only just begun to be explored. Coatings have been applied with proven success to such widely dissimilar items as gears and pinions, surveying instrument parts, turbine impeller blades, hand tools, the leading edges of high-speed airfoils, and leg braces for paraplegics.

The Martin hard coating is applied to aluminum and its alloys by an electrochemical process, which creates a nonmetallic, highly heat refractive surface—strongly bonded to the base metal. Coating thicknesses range from .0001 to .006 in.—with abrasion-resistant uses as a rule calling for .002 in. Surface smoothness, in general, is closely maintained by the processing. The hardness of the coating may be considered "file hard".

For further information circle No. 691 on literature request card on p. 296B

ENGINEERING DIGEST OF NEW PRODUCTS

"GUN GUARD" OIL SPRAY: A new type rust preventive oil and lubricant known as "Gun Guard" and packaged in an Aerasol container for spray application to metal parts and fabrications in storage and production, guns, firearms, tools, implements, fishing reels, etc., has been introduced by The Mitchell-Bradford Chemical Company.

"Gun Guard" Oil, due to its excellent corrosion resistance characteristics and spray application, is ideal for industrial use due to the speed and ease with which it can be applied without the necessity of having to lift or move the items to be treated. Parts or assemblies either in storage bins or production lines can be easily and conveniently sprayed with "Gun Guard" Oil.

The oil is a polarized type and will displace any wetness or dampness on the metal surfaces resulting in longer corrosion resistance. Because of the spray application the oil will reach areas, especially in assembled mechanisms, which normally are hard to reach.

For further information circle No. 692 on literature request card on p. 296B

PACKLESS HIGH VACUUM VALVES: High vacuum valve requirements may be filled with significant economy by National Research Corporation's new packless high vacuum bellows valves, especially designed for vacuum or other applications which require a very low rate of leakage.

These valves are fabricated from high quality bronze bodies. A long life brass bellows is used to completely seal off the valves from atmospheric pressure, independently of valve position. The standard seat supplied is Neoprene, but other seats, such as Teflon, are available for special applications.

Each valve is individually tested on a mass spectrometer-type leak detector, which is capable of detecting leaks of less than 0.01 micron cubic feet per hour, thus assuring the quality necessary for high vacuum use.

Available at present are 1, 1½, 2 and 3-in. i.p.s. valves of the globe screw and globe flange type. They are stock items, ready for immediate delivery.

For further information circle No. 693 on literature request card on p. 296B

INSPECTION METHOD FOR METALS: Turbodyne Corporation, a subsidiary of Northrop Aircraft, Inc., has developed a revolutionary metal inspection process known as Dy-Chek, which promises great benefits to manufacturers and users of high-strength, precision-built machinery and equipment.

This process depends upon the controlled use of a red dye, together with other liquids, to indicate the presence of cracks or other flaws too small to be seen even with a magnifying glass. When applied to the surface of the suspected metal, the Dy-Chek process causes a crack or other opening to "bleed" in telltale scarlet lines which emerge almost magically, and with photographic clarity, against a white background.

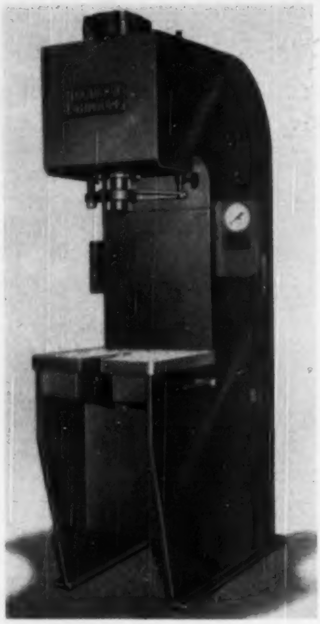
Chief advantages claimed for the new process over available methods are its relative inexpensiveness — no elaborate equipment is required; its simplicity; its application to both ferrous and nonferrous metals; its portability, and its accuracy.

For further information circle No. 694 on literature request card on p. 296B

ENGINEERING DIGEST OF NEW PRODUCTS

NEW 10-TON HYDRAULIC FORCING PRESS: A simplified design for quantity production is credited by Hannifin Corporation for the surprisingly low price and the almost immediate delivery offered on their new 10-ton hydraulic forcing press, Model F-101. Yet the new design results in a press with proper rigidity of frame, precise machining of the cylinder and ram, and controls that are easy to operate.

The F-101 is floor-mounted, with an 18 by 20-in. table 36 in. above the floor. Standard models have a 3-in. "U"-slot in the table. Gap or "daylight" is 22 in.; reach is 10 in.; and maximum stroke is 12 in. Completely self-contained, with a 5 hp. vertical motor and an 11 gpm. constant volume pump, the press has an adjustable relief valve which makes it possible to set maximum pressure at any point from 10% of capacity to full, 10-ton capacity. The ram is guided to prevent rotation and return stroke is adjustable so cycle time can be reduced considerably on applications where full stroke is not needed. **For further information circle No. 695 on literature request card on p. 296B**



LUBRICANT FOR DEGREASERS: Effective lubrication of conveyor chains which pass through vapor degreasers cannot be accomplished with ordinary petroleum products. There is one high temperature lubricant that is successful in this application because of its chemical inertness. It is colloidal graphite, a microscopically fine substance which lubricates effectively from sub 0° to 3000° F. plus. Because of its extreme chemical inertness it is unaffected by degreaser solvents.

One manufacturer of colloidal graphite, Acheson Colloids Corporation, recommends that colloidal graphite dispersed in alcohol be used on degreaser chains. The alcohol acts as a medium to transport the graphite to the points requiring lubrication. It is usually applied immediately after the chain leaves the degreaser tank and while it is still warm. By the time the chain completes its cycle and returns to the tank the alcohol has evaporated and the dry lubricating film is in position to carry the load. **For further information circle No. 696 on literature request card on p. 296B**

ENGINEERING DIGEST OF NEW PRODUCTS

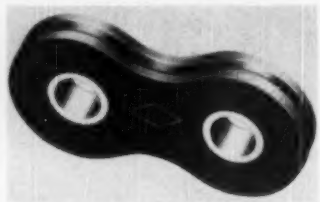
PRECISION INSTRUMENT OILS: Two new "synthetically tailored" lubricants, recommended for use in virtually all fine precision instruments, are being introduced by the Gulf Oil Corporation.

The lubricants, Gulf Special Instrument Oil and Gulf Micro Bearing Oil, are the result of years of research by Elgin National Watch Company working in collaboration with the Gulf Research Fellowship at Mellon Institute of Industrial Research in Pittsburgh. The two oils are wholly synthetic products with special properties which adapt them particularly to the lubrication of small, delicate, low-torque bearings encountered in precision instruments. This non-spreading quality enables them to "stay put" over long periods of time when applied in minute quantities to small pivot-to-jewel or pivot-to-brass bearings.

In addition to their non-spreading tendencies the oils are highly resistant to oxidation and are exceptionally low in volatility, thus permitting their use over prolonged periods of time with a minimum of gumming or thickening. Where maximum length of service between application periods is desired, Gulf Micro Bearing Oil is generally preferred.

For further information circle No. 697 on literature request card on p. 296B

CONNECTING LINKS FOR DIAMOND ROLLER CHAINS: A patented bushed center plate Connecting Link has been developed for use with Diamond multiple-strand Roller Chain for severe service. This Connector



made by Diamond Chain Company, Inc., provides durability, closely matching that of the Diamond press-fit center plate multiple-strand chain. The same ease of connecting and disconnecting the chain is thus provided as with slip-fit center plate design links, thus simplifying the handling of multiple-strand chains. The new Connectors, which are being produced for ⅝ in. through 2½-in. pitch Diamond multiple-strand Roller Chains, have file-hard bushings pressed into pitch holes of pairs of center plates making one unit with the bushings, then ground for hole and pitch accuracy. Since full support is provided across all strands and both pins and bushings are hardened and polished, wear is greatly reduced.

For further information circle No. 698 on literature request card on p. 296B

INDUCTION HEATING TECHNIQUE: A new technique for the induction heat-treating of nonferrous metal strip such as aluminum, brass, copper, magnesium and stainless steel — called "Transverse Flux Induction Heating" — was recently revealed by Westinghouse Electric Corporation.

Transverse flux induction heating is accomplished by passing strip between two opposing laminated pole structures. The field coils, supplied with alternating current, are oppositely polarized so that flux is forced through the strip. Frequencies of from 60 to 10,000 cycles per second are used with this system, depending on the thickness of the strip and its resistivity.

Transverse flux induction heating although still in the experimental stage, is proving itself very effective.

For further information circle No. 699 on literature request card on p. 296B

NARCOIL-30: Consistent with a policy of expanding vacuum service to industry, National Research Corporation announces Narcoil-30 diffusion pump fluid. This new product satisfies the requirements for a good quality diffusion pump fluid at a moderate price. It supplements the company's line of standard pump fluids, Narcoil-10 and Narcoil-20, and should not be confused with the latter which was recently announced.

Narcoil-30 is di-2-ethylhexyl phthalate specially treated and tested for high vacuum use. It is recommended for use in diffusion pumps operating at pressures above 2×10^{-3} mm. Hg. Narcoil-30 is the standard type of fluid used in cathode-ray tube plants and electronic tube plants in general.

For further information circle No. 700 on literature request card on p. 296B

ENGINEERING DIGEST OF NEW PRODUCTS

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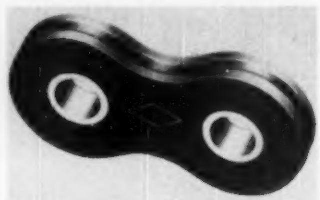

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For further information circle No. 700 on literature request card on p. 296B

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

701. Alloy Handbook
New pocket-size Alloy Handbook. It's a mine of nonferrous alloy information — and it's yours for the asking. *Riverside Metal Co.*

702. Alloys, Fabricated
New catalog is available, showing cost-cutting fabricated heat treating equipment for higher pay loads and better quality. *Rolock, Inc.*

703. Alloys, Nickel
Technical bulletin, "Cast 16% Cr–35% Ni Alloys", completely illustrates heat, corrosion and abrasive-resistant cast alloys. *Electro Alloys Div.*

704. Belts, Metal
Bulletin 47F illustrates and describes complete line of wire belts for industry. *Ashworth Brothers, Inc.*

705. Beryllium-Copper
New technical bulletin No. 1 gives case history and technical information on Berylco 165 strip. First in a series of data sheets to provide the engineer with facts on beryllium copper. *The Beryllium Corp.*

706. Cast Irons
"Production of Nodular Cast Irons with Cerium" gives details of actual practice in adding cerium to the foundry melt as developed by the British Cast Iron Research Association. First release in America. *Cerium Metals Corp.*

707. Castings
Bulletin FC-350 outlines the many advantages of improved Fahrite corrosion-resistant castings. *Ohio Steel Foundry Co.*

708. Cleaning Machine
Carbo-cleaner, the most compact, lowest priced carburizing-compound-cleaning machine on the market. Write for further details. *Thurner Engineering Co.*

709. Combustion Safeguard
Bulletin F2-2 furnishes complete information on the new Wheelco 1300 Flame-otrol control unit with plug-in programming cycles for safety, economy and uninterrupted operation. *Wheelco Instruments Co.*

710. Combustion Tubes
Bulletin 314 gives full description of mullite and zircon combustion tubes designed especially for high temperature laboratory use and offered at new low prices. *Burrell Corp.*

711. Corrosion
Complete line of quality rust preventives, both oil and petrolatum types for interior and exterior use, described in booklet "Gulf Rust Preventives". *Gulf Oil Corp.*

712. Descaling
Booklet entitled "duPont Sodium Hydride Descaling Process" discusses the process, how it works and where it is used, along with interesting photographs, diagrams and technical information, designed to help you get the most out of your scale-removal jobs. *E. I. duPont de Nemours & Co., Inc.*

713. Engineering Drawings
New 16-page booklet, "Modern Drawing and Document Reproduction", describes methods for improving legibility of engineering drawings and business documents. Provides information on reproduction of tracings, blueprints and opaque drawings on paper, film and cloth, with specialized recommendations for restoring old drawings and eliminating hand tracings. *Eastman Kodak Co.*

714. Extrusions
"Alcoa Aluminum Extruded Shapes" is the title of a new booklet describing the many advantages of these low-cost light metal shapes. Contains interesting illustrations and diagrams of all types of design and assembly, as well as a helpful terminology index and complete charts of mechanical properties and tolerances for extrusion alloys. *Aluminum Co. of America.*

715. Finishes
Bulletin 1400 tells how the new Hydro-Finish provides cleaner, smoother surfaces prior to coating processes; saves hours on the production line. *Pangborn Corp.*

716. Finishing
Alodine aluminum bonds paint to aluminum and protects the metal economically, with no plating equipment required. Applied with dip, spray, brush and float coat, it provides a simple, easy process for lasting, corrosion-resistant finish. *American Chemical Paint Co.*

717. Free-Machining Bar Steel
Reprint of article entitled "La-Led, A New Free-Machining Bar Steel", by Glenn D. Bayer, metallurgist at LaSalle Steel, discusses the advantages and characteristics of the new steel. *LaSalle Steel Co.*

718. Furnace Controls
Information available on the Speedomax recorder that automatically plots the relationship between two variables, showing one as a function of the other. Tedious compilation and manual plotting by experienced personnel are eliminated. *Leeds & Northrup Co.*

719. Furnaces
Bulletin HD-441 gives construction details and complete specifications on 20 sizes and types of furnaces for laboratory use. *Hevi Duty Electric Co.*

720. Furnaces, Annealing
Vertical strip annealing furnaces improve silicon steel production and provide excellent surface characteristics which increase stamping die life. *Drever Co.*

721. Furnaces, Sintering
New 8-page bulletin 230 illustrates and describes the complete Lindberg line of sintering furnaces. Also includes description of atmosphere generators for use in conjunction with this furnace. *Lindberg Engineering Co.*

722. Galvanite Handbook
A new 12-page, illustrated handbook explaining the uses, manufacture, and advantages of Galvanite, a special hot-dip, zinc-coated steel produced by this company. *Sharon Steel Corp.*

723. Gas-Analysis Equipment
New "Gas-Analysis Manual" contains authoritative technical information on gas analysis with a description of all units, including those with the new ball-and-socket connectors, and a complete current price list. *Fisher Scientific Co.*

724. Gas Generator
Bulletin 1-11 describes how fully automatic generator Model 1 M1HE, rated 1000 c.f.h., gives accurate proportioning and assures precise analysis over full operating range. Ratio control adjusts for manufactured, natural, propane, butane or refinery gases. *C. M. Kemp Mfg. Co.*

725. Gray Iron
Revised summary of Gray Iron specifications available in 4-page bulletin containing a resume of fourteen separate sets of gray iron specifications including a change in ASTM A-159-47 to ASTM A-159-49T and the addition of two new specifications covering automotive irons 113 and 114. *Gray Iron Founders' Society.*

726. Grinding Wheels
4-page bulletin ESA-191 illustrates grinding wheels for plain cylindrical grinding and includes grain and grade recommendations in addition to popular wheel sizes and data on speeds and feeds. *Simonds Abrasive Co.*

727. Hardness Tester
Illustrated circular describing the Ames portable hardness tester in sizes for work 1 to 6 inches round and flat. *Ames Precision Machine Works.*

728. Hardness Testers
Bulletin DH-114 contains full information on Tukon hardness testers for use in research and industrial testing of metallic and nonmetallic materials. Also included is bulletin DH-7, giving experiences in various fields. *Wilson Mechanical Instrument Co.*

729. Hardness Testers
New information available on the Brinell hardness, transverse, tensile, ductility, compression and hydrostatic testing machines. *Steel City Testing Machines, Inc.*

730. Heat Treating
Bulletin 123 describes how production is doubled, surface protection improved, and life of tools increased through the use of Ajax salt bath heat treating equipment. *Ajax Electric Co.*

731. Immersion Heating
Bulletin SC-142 describes suction and atmospheric burner types of immersion heating equipment as used in typical applications such as heating solutions in tanks, salt-type descaling baths, heating oil tanks, spray and alkali washers. *Surface Combustion Corp.*

732. Induction Heating
More economical production made possible through redesign of heat treating methods. Full details on application to individual plants furnished in booklet, "A Tocco Plant Survey — Your Profit Possibility for 1950". *Ohio Crankshaft Co.*

733. Industrial Planning
New book 127 tells how you can share in a "round-table" discussion of planning expansion, remodeling or modernization of your plant. *Continental Industrial Engineers, Inc.*

734. Insulating Compound
New vinyl insulating compound, especially designed for high-temperature service, protects iron constantan and copper constantan thermocouple lead wires. Write for further information. *B. F. Goodrich Chemical Co.*

735. Lubricants
Interesting facts on how shop operation can be more efficient and economical through the use of right lubricants described in "Metal Cutting Fluids". *Cities Service Oil Co.*

736. Lubrication of Hot Metals
New bulletin 426 describes how (DAG) colloidal graphite can solve your lubrication problems in hot metal forming operations. *Acheson Colloids Corp.*

737. Machine Design
Fundamentals of producing low-cost machine parts — design, material and treatment — are discussed in new 72-page "Three Keys to Satisfaction". *Climax Molybdenum Co.*

738. Machining Steel
Complete information on accurate, economical turning, drilling and reaming operations furnished in "Notebook on Machining Stainless Steels" sent on request. *Carpenter Steel Co.*

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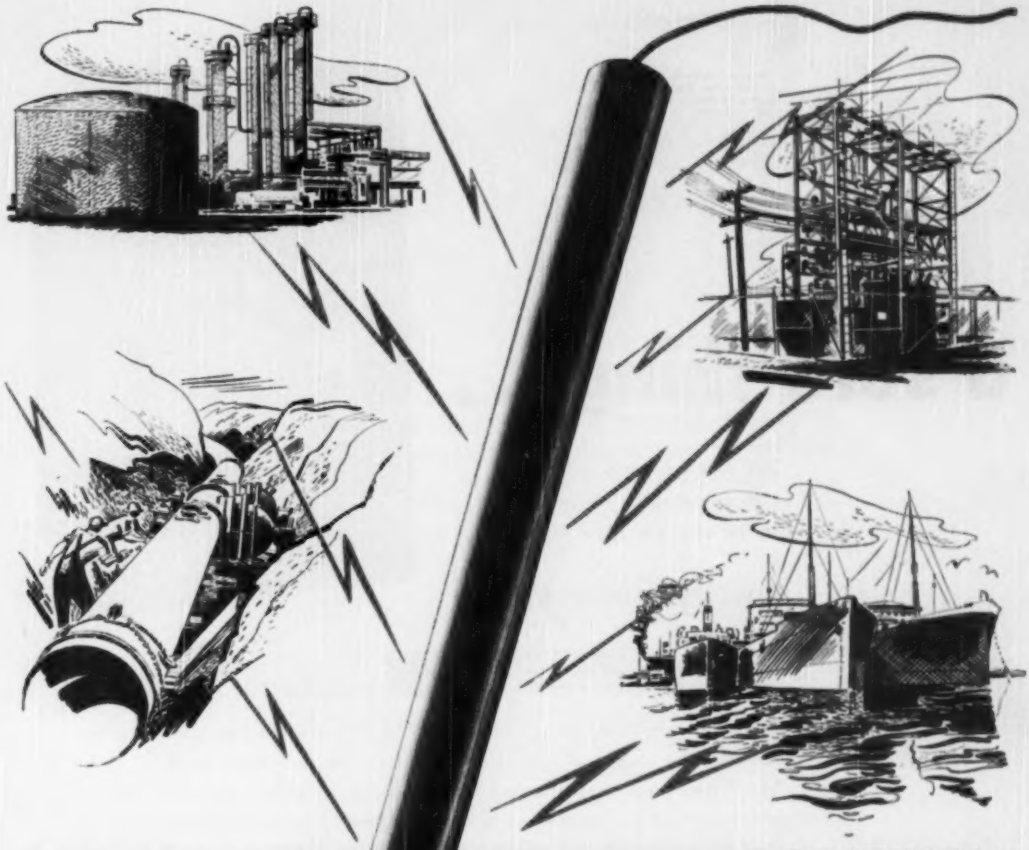

PROTECT METAL STRUCTURES POSITIVELY UNDER ALL CONDITIONS!

"NATIONAL" GROUND ANODES

● Regardless of what the job is . . . how corrosive the environment — whether wet or dry, hot or cold — you can depend upon "National" ground anodes to provide efficient, positive protection against underground and underwater corrosion.

"National" ground anodes have proved themselves in 20 years of successful operation in many different parts of the country. They outlast other materials by a wide margin. They do not have to be dug up and replaced every couple of years. Because they use a controllable current source, it is simple and economical to adjust their protective output to match exactly the requirements of any installation.

For complete details on "National" ground anodes, write to National Carbon Division, Union Carbon and Carbide Corporation, Dept. Z.

MORE THAN DOUBLE THE USABLE LIGHT!

The biggest news since the invention of flashlights—the brand new leakproof "Eveready" No. 1050 flashlight battery—gives more than double the usable brilliant white light for critical uses than any other flashlight battery we ever made.

NO METAL CAN TO LEAK OR CORRODE

The terms "National" and "Eveready" are registered trade-marks of

NATIONAL CARBON DIVISION

UNION CARBIDE AND CARBON CORPORATION

30 East 42nd Street, New York 17, N. Y.

District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

Foreign Department: U. S. A.

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

739. Metal Spinning
New Spincraft data book — a valuable reference bulletin that illustrates lower costs made possible through pioneering developments in working of metals. *Spincraft, Inc.*

740. Microcastings
This 16-page booklet describes many applications for microcasting and also explains the process itself. *Microcast Div., Austenal Laboratories.*

741. Micro-Hardness Tester
Descriptive leaflet on Mh micro-hardness indenter, a new instrument for measuring hardness of microconstituents, fine wire, metallic foils, electrodeposited coatings, etc. Adaptable to table microscopes, simple to operate and low in cost. *Erb & Gray.*

742. Microscopes
Catalog D-1010 illustrates and describes new E series of microscopes for the most exacting research work. *Bausch & Lomb Optical Co.*

743. Nickel Alloys
Bulletin T-7 contains 24 pages of new data on high nickel alloy Inconel, with tables on compositions and properties as well as information on "Inconel X" one of the newer age-hardenable Inco nickel alloys. *International Nickel Co.*

744. Oil Quenching
Catalog V-1146 gives detailed information on self-contained oil coolers, together with easy selection tables. *Bell & Gossett Co.*

745. Ovens
Bulletin No. 118 gives complete details of bench-type oven with advance design and rugged construction for efficient heat processing to 500°F with gas or electric heating. *W. S. Rockwell Co.*

746. Paint Primer
"Protecting Gas Holders" is the title of the latest in a series of booklets outlining the advantages of silica graphite paint in reducing yearly maintenance costs of gas holders. Also provides valuable data on protection of metal structures of all types. *Joseph Dixon Crucible Co.*

747. Photomicrographic Camera
New folder furnishes a full description of the Gamma "U" camera and its complete line of accessories for micro, low power, macro and copying work. *Gamma Instrument Co.*

748. Plating Generators
For electroplating, anodizing, electrocleaning or electropolishing in either large-scale or small operations, there's a Columbia M-G set available for you. Catalog MP-700 sent free on request. *Columbia Electric Mfg. Co.*

749. Polishing
New booklet on the Electro Polisher gives latest information on this highly improved polishing machine for the metallurgical laboratory. *Buehler, Ltd.*

750. Pyrometer
Catalog No. 80 illustrates and describes the Pyro Optical Pyrometer for quick, accurate temperature readings on minute spots, fast-moving objects and small streams in a temperature range from 1400°F to 7500°F. *The Pyrometer Instrument Co.*

751. Refractories
Complete details on refractory cements for every nonferrous melting operation are available in catalog 863. *Norton Co.*

752. Refractories
New booklet on KX-99 refractories for the steel industry tells how these furnace bricks were developed especially with low porosity and high bulk density, for tough, hard wear in bottoms of blast furnaces. *A. P. Green Fire Brick Co.*

753. Refractories
Announcing a new general bulletin MCC 1, which briefly describes the complete line of chemical construction materials, including: corrosion-proof linings, cements, brick sheathings, protective coatings and acid-proof brick and tile. Also contains handy estimating data. *Atlas Mineral Products Co.*

754. Sawing Handbook
Announcing the first edition of the Circular Sawing Handbook No. 240. This 24-page pocket-size book contains valuable information on operation of sawing machines and how to overcome difficulties encountered. Includes tables for proper selection of blades, operating speeds and feeds and tooth angles for ferrous and nonferrous materials. *Motch & Merryweather Machinery Co.*

755. Springs
New two-color bulletin describes, by engineering drawings and application photographs, the four major forms of the neg'ator — an elastic member possessing either constant or negative force-deflection characteristics. *Hunter Spring Co.*

756. Stainless Steels
Full information, including prices, is available on advantages of free-machining Enduro stainless steel. *Republic Steel Corp.*

757. Stainless Steels, and Tubing
New engineering memorandum on "Resistance to Sensitization of Extra Low Carbon Stainless Steels" now available showing comparative tests on various types for corrosion immunity after welding. *Peter A. Frasse & Co.*

758. Steel Selector
Handy, clearly printed, easy-to-use tool steel selector will be furnished on request. *Crucible Steel Co. of America.*

759. Steels, Alloy
New book is now available on the selection of the proper alloy steel grades for each manufacturer's needs. Write for free copy of "Wheelock, Lovejoy Data Book". *Wheelock, Lovejoy & Co.*

760. Temperature and Pressure
Two measuring instruments for exhibiting and controlling temperature and pressure. Catalog 86 describes "Ratotherm" with thermal systems filled with liquid or gas for ranges between −125°F and +1000°F and "Ratogage" with bellows and multiple-diaphragm, covering ranges between 30 inches of mercury vacuum and 10,000 psi. *Fischer & Porter Co.*

761. Tempilstiks°
"Basic Guide to Ferrous Metallurgy", a plastic laminated wall chart in color, furnished on request. *Tempil° Corp.*

762. Tensile Testing
Handy, slide-rule-type calculator for computing tensile strength on both round and rectangular specimens, furnished on request. *W. C. Dillon & Co.*

763. Testing
Bulletin 41 describes new universal testing machine for low-cost industrial production and quality control, laboratory, educational, and shop testing of metals. *Tinius Olsen Testing Machine Co.*

764. Testing
Bulletin 2005 describes new high speed automatic "Cyclograph" equipment for non-destructive sorting and inspection of metal parts by their metallurgical characteristics. Sorting speeds of 1 to 5 parts per second can be obtained. *J. W. Dice Co.*

765. Thermocouples
A new 34-page catalog, Reference H, will furnish complete data on thermocouples, quick-coupling connectors, thermocouple wire, lead wire, protection tubes, etc. *Thermo Electric Co.*

766. Tool Steels
Countless advantages of using J & L "E" steels for better tool production described in booklet, "Faster Machining, Smoother Finish, Longer Tool Life". *Jones & Laughlin Steel Corp.*

767. Tube Bending
Special 50th anniversary 60-page catalog provides a complete file listing of bending, warehousing and fabricating of pipe and tubing for every application. *Wallace Supplies Mfg. Co.*

768. Tubing
For full information on solving your tubing problems and details on particular uses of seamless and weldrawn types, send for bulletin 31. *Superior Tube Co.*

769. Tubing
A new well-illustrated, 16-page booklet describes cost cutting with close-tolerance tubing, covering ferrous, nonferrous and bimetal applications. *Tube Reducing Corp.*

770. Turbines
Bulletins available as follows: Data book 107, Gas Boosters 109, Four-Bearing 110, Blast Gates 122, Foundry 112, Descriptive bulletin 127 and Technical bulletin 126. Send for each by number for particular application. *Spencer Turbine Co.*

771. Valves, Safety
New series "LT" Lock-Tite safety valve making possible instantaneous gas shut-off under any or all unsafe conditions. Described in bulletin M-302. *Eclipse Fuel Engineering Co.*

772. Welding
Bulletin 9, "Fabrication of Aluminum", gives factual information on complete and specialized facilities for the design and fabrication of aluminum. *Welding Engineers, Inc.*

773. Welding
Information available on Oxweld W-17 blowpipe with right welding head or cutting attachment for high efficiency and economy in all types of welding processes. *Linde Air Products Co.*

774. Welding Stainless Steels
For all users of welded stainless steel equipment, a detailed account of the properties of extra-low-carbon stainless steel is provided in technical paper, "Resistance to Sensitization of Austenitic Chromium-Nickel Steels of 0.03% Max. Carbon Content". *Electro Metallurgical Co.*

775. Batch-Type Furnace
Four-page illustrated folder on new batch-type furnace for controlled atmosphere heat treating has just been made available by Holcroft and Company. The folder discusses the completely automatic cycle of the batch-type furnace. Drawings covering the cycle and suggestions on how the furnace can fit into production lines are included. New features are also described: radiant heating with temperature build-up; vestibule flushing for clean, scale-free parts; compact size — no pit needed; long tray life; controlled quench temperature and agitation; and others.

[• If mailed from countries outside the United States, proper amount of postage stamps must be affixed for returning card]

METAL PROGRESS
7301 Euclid Avenue, Cleveland 3, Ohio

September, 1950

689	707	725	743	761
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691	709	727	745	763
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704	722	740	758	
705	723	741	759	
706	724	742	760	

Please have literature circled at the left sent to me.

Name ______________________ Title ______________

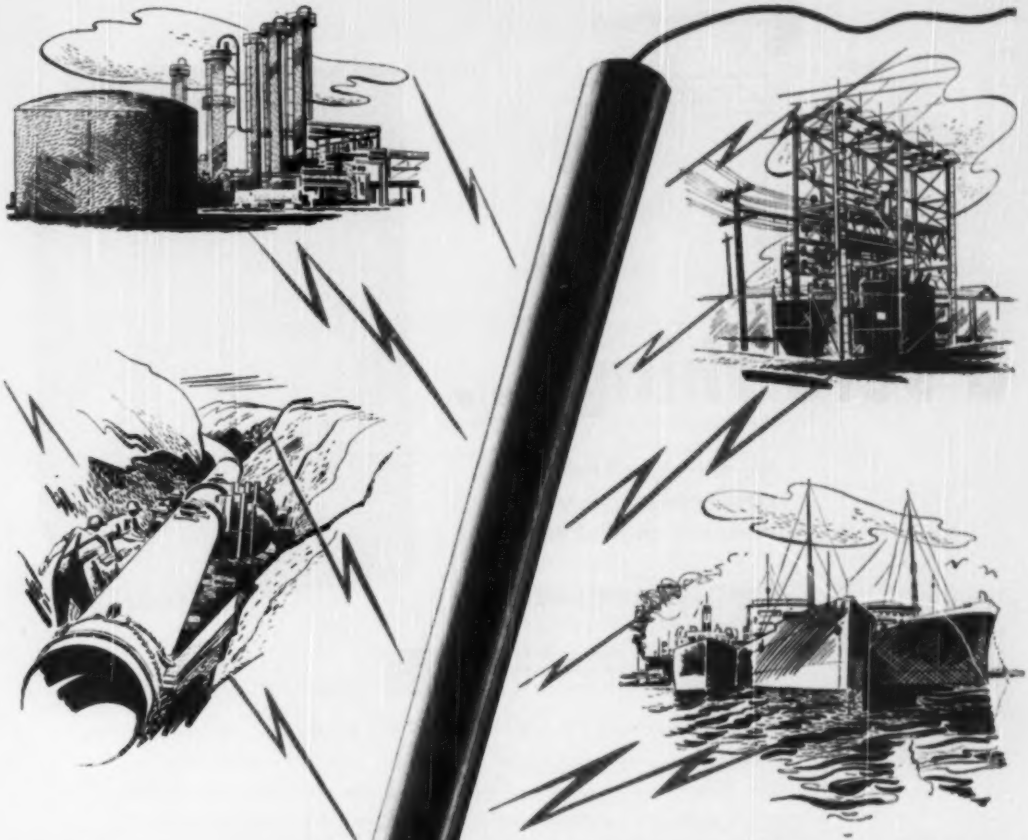
Company ______________________

Products Manufactured ______________________

Address ______________________

City and State ______________________

Postcard must be mailed prior to December 1, 1950—
Students should write direct to manufacturers.

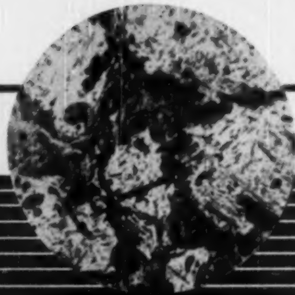


EVEREADY

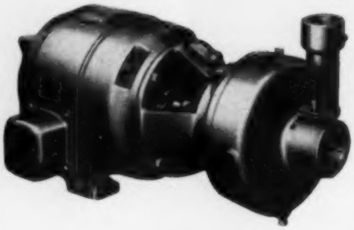
GALVANITE
MAKES BETTER PRODUCTS FOR
ELECTRICAL MANUFACTURERS
The special tight bond of zinc to steel makes Galvanite* the most desirable material where severe fabrication of rust-repelling steel is necessary. The finish stays put—cutting reject losses and adding to sales appeal. It doesn't flake or peel or coat dies—saving production time and costs. For the same reasons it won't fail—bringing everlasting customer satisfaction. For electrical hardware—or anything else that requires zinc coat steel—there's nothing better than Galvanite*.
Galvanite Is NOT Shiny
The special patented process employed in the manufacture of Galvanite* gives the steel a grey finish. Do not expect a shiny, tinny appearance. Most products made of Galvanite* are hidden or painted—therefore Sharon makes no attempt to beautify the steel. Only high quality at standard prices are considered in its manufacture.
*T. M.
For Quality Electrical Sheet, Stainless, and Special Alloys, Too, Specify Sharon—Fine Steels For More Than Fifty Years
SHARONSTEEL
SHARON STEEL CORPORATION
Sharon, Pennsylvania

The grain you want

Is the grain you get



...WHEN YOUR QUENCHING IS *Controlled*



B & G SERIES 1522 CENTRIFUGAL PUMPS

Here's a completely outstanding pump, offering features which eliminate many usual pump troubles. Its mechanical seal eliminates a stuffing box—prevents leakage—permits handling of difficult liquids without trouble. Other features include standard motor, spring-type flexible coupling and interchangeable parts.

B & G QUENCH TANKS

Quench tank design is an important factor in obtaining proper cooling at minimum operating expense. Correct sizing and shaping frequently result in lower auxiliary equipment cost and contribute to better over-all control.

B & G Quench tanks are made in standard shapes or can be designed to your specific requirements. Their construction assures maximum turbulence of the oil, preventing formation of vapor bubbles and consequent irregular surface hardness.

Your heat treating operations are designed to produce a definite metal structure—do your quenching methods preserve it?

For assurance of uniform quality in your finished product, you can do no better than to install a B & G *Hydro-Flo* Oil Quenching System. You can assemble the system from separate B & G Oil Cooler components, or do as so many heat treaters are doing today—install a B & G Self-Contained Unit as illustrated above.

It's factory-assembled, complete in every detail, needing only connection to oil and water lines for immediate operation.

Send for B & G Catalog V-1146. It gives you complete information on B & G Self-Contained Oil Coolers, together with easy selection tables.

Hydro-Flo*
OIL QUENCHING SYSTEMS

BELL & GOSSETT COMPANY

Dept. BS-16, Morton Grove, Ill.

*Reg. U. S. Pat. Off.


QUESTION:
"HOW CAN I CUT MY FORGING COSTS?"
ANSWER:
"REDUCEROLL YOUR FORGING BLANKS!"
NO. 1 REDUCEROLL
NO. 2 REDUCEROLL
NO. 4 REDUCEROLL
NO. 6 REDUCEROLL

REDUCEROLL FIELD REPORTS

How successfully National's new REDUCEROLL substitutes simplicity and economy for costly forging practices in the preparation of forging blanks, is indicated in the following testimonials. Statements refer to routine, in-production operations.

CASE 1

"Application of REDUCEROLLS to our connecting rod line makes possible an 81% increase in production rate . . . already getting 60%."

CASE 2

"Saving 1.5 pounds of stock per double steering arm forging."

CASE 3

"Aircraft connecting rod production increased 125% . . . grain flow better . . . saving two pounds of steel per forging."

CASE 4

"Will save more than four pounds per piece . . . producing 150 per hour."

CASE 5

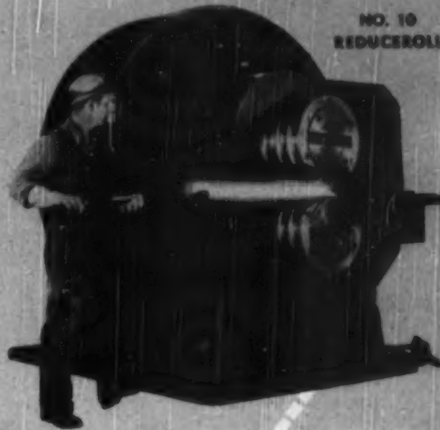
"Automotive spindle support . . . saving 1.5 pounds per double forging."

CASE 6

"Saving 1.21 pounds of stock per rod forging."

CASE 7

"Nearing 200,000 axle shafts preformed . . . still using original non-heat-treated rolls."

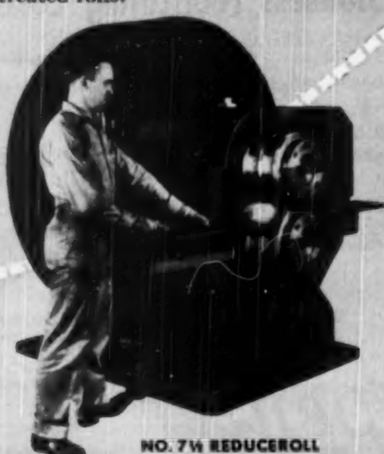


NO. 10 REDUCEROLL

In the field less than two years, the rugged REDUCEROLL has already distinguished itself for versatility and dependability in leading forge plants. Typical REDUCEROLL advantages include:

1. **Higher production.**
2. **Savings of material.**
3. **Increased forging die life.**
4. **More uniform forgings.**
5. **Less wear and tear on heavier forging equipment.**
6. **Portability—"roving tool."**
7. **Ease of operation.**
8. **Low-cost rolls quickly interchangeable.**

Our entire organization is available to help you investigate the application of new forging techniques to your jobs. Send us a print or sample of the part you wish to forge. Better yet, pay us a visit. No obligation, of course.



NO. 7½ REDUCEROLL

NATIONAL MACHINERY COMPANY
TIFFIN, OHIO

DESIGNERS AND BUILDERS OF MODERN FORGING MACHINES—MAXIPRESSES—COLD HEADERS—AND BOLT, NUT, RIVET, AND WIRE NAIL MACHINERY

New York Detroit Chicago

G·E FURNACES

fire enamelware better with few rejects, low upkeep

AS REPORTED BY...

Ralph E. Taylor, Plant Manager The Enamel Products Company, Cleveland, Ohio

"We installed our first General Electric porcelain enameling furnace 20 years ago. That same furnace is still turning out top-notch enamelware at low cost and at high-production rates. We have had few rejects, no warpage and NO emergency shutdowns.

"Since installing our first G-E furnace in 1930 we have purchased three additional furnaces—one box-type and two continuous, counter-flow, heat-sealed furnaces . . . all General Electric. In addition to our regular enamelware, we are also firing KOROK, our newly developed table-top material, in these furnaces with excellent results!"

To help you turn out better products, faster, and at lower cost, General Electric offers a complete line of electric furnaces and associated equipment, including atmosphere producers. Contact the G-E Sales Office nearest you, or write: *Apparatus Department, General Electric Company, Schenectady 5, N.Y.*

ELECTRIC FURNACES

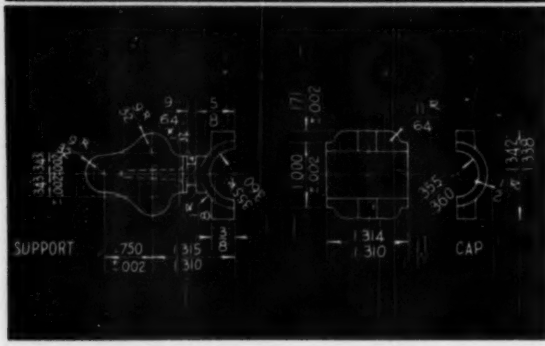
Annealing Brazing Drawing
Carburizing Enameling Hardening
Normalizing Sintering
Steel Mill Applications

GENERAL ELECTRIC

MISCO *Precision* CASTINGS

CARBON AND STAINLESS STEEL

CAST TO MICROMETER TOLERANCES



Part:

BRACKET SUPPORT AND CAP (AIRCRAFT)

Alloy: Miscrome 1 *Weight: 5.2 oz.*

(A.I.S.I. Type 420 Nominal)

Both parts of this actuator assembly are precision-cast to close tolerances. The use of this process eliminated forging die expenses, and resulted in great reduction of machining cost.

These two parts, made to the highest aircraft material specifications, are splendid examples of our ability to precision-cast in large quantities parts which would be uneconomical to produce by the usual machining methods. Why not consider the Misco Precision Casting Process for low-cost production of your small intricate parts in high strength, wear resistant, and heat and corrosion resistant alloys. We solicit your inquiries and will assist with the design, material and manufacturing details.

Send FOR BOOKLET "MISCO Precision Castings"

The striking qualities of the Misco Precision Casting Process, described in our booklet, are of particular interest to engineers, metallurgists, production and purchasing executives. If your requirements call for quantity production of small complex parts in high strength, wear resistant, and heat and corrosion resistant steel alloys you need this booklet.

PRECISION CASTING DIVISION
Michigan Steel Casting Company

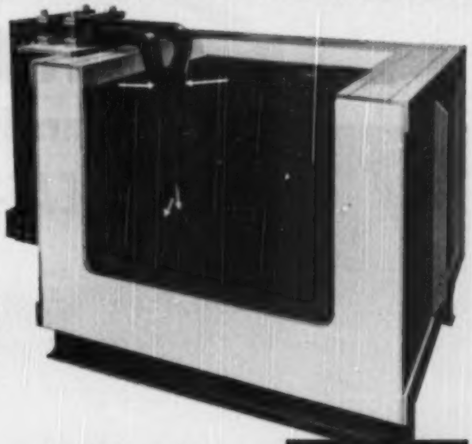
MISCO
Heat and Corrosion Resistant Alloys

One of the World's Pioneer Producers and Distributors of Heat and Corrosion Resisting Alloys

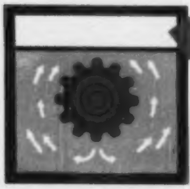
1998 GUOIN STREET · DETROIT 7, MICHIGAN

THE MOST EFFICIENT HEAT TREATING PRINCIPLE

...for CARBURIZING • CYANIDE HARDENING NEUTRAL HARDENING • ANNEALING OR HARDENING STAINLESS STEEL • BRAZING • HARDENING HIGHSPEED STEEL • AUSTEMPERING • MARTEMPERING • PROCESS ANNEALING • CYCLIC ANNEALING DRAWING (TEMPERING) • SOLUTION HEAT TREATMENT • DESCALING • DESANDING • CLEANING

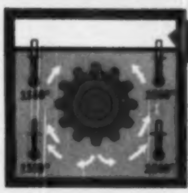


In the Ajax Electric Salt Bath, utilizing immersed electrodes, all heat is generated within the bath itself—the liquid salt acting as a "resistor". Electrodynamic forces produce vigorous circulation throughout the bath, in the *downward* motion indicated. This is precisely opposite to the *upward* thermal flow—dependent on a temperature difference in a bath—which exists in other salt bath furnaces. Only Ajax offers electrodynamic circulation!



RAPID HEATING BY CONDUCTION

The rate of heating depends only on the heat conductivity of the work itself. Thus, the Ajax Salt Bath Furnace heats work 4 to 6 times faster than a radiation type or forced convection furnace.



UNIFORM HEATING

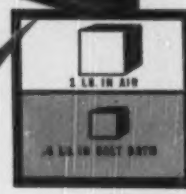
The liquid salt completely surrounds the work and the automatic stirring action transmits uniform heat to all surfaces simultaneously. No other method delivers such heating uniformity—within 5° F. or *less* at any part of the bath.

NO ATMOSPHERE PROBLEMS

The Ajax Electric Salt Bath Furnace eliminates *all* atmosphere control problems. Scaling, oxidation and decarb are avoided. First cost of gas generating equipment as well as its operating expense are eliminated.

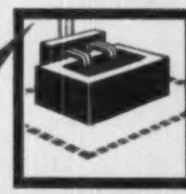
AUTOMATIC PREHEATING

When a cold piece of metal is immersed, a "cocoon" of frozen salt forms around it instantly. This layer serves as a temporary insulator, preventing temperature shock and too sudden heating. The frozen salt melts in a minute or less and the work then heats rapidly to bath temperature.



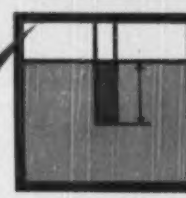
BUOYANCY THAT MINIMIZES DISTORTION

Although the work sinks readily into the liquid salt, the bath nevertheless supports it to a marked degree. In effect, the work weighs appreciably less when immersed and this tends to prevent distortion and warpage.



MORE PRODUCTION IN LESS FLOOR SPACE

Because an Ajax furnace heats work so much faster—and because it eliminates the need for atmosphere generators and similar bulky auxiliary equipment, a proportionately smaller amount of floor space is required to handle a given volume of work.



SELECTIVE HEATING

Because of its rapid heating rate, only that portion of the work immersed in the bath is heated. Just dip and treat any *desired portion* of any metal part or assembly.

NO SKILLED LABOR

Operation is so entirely automatic, so closely controlled by the Ajax furnace itself, that even an unskilled operator can handle full production.

72 pages of factual heat treating data! Write for Catalog 116 on your company stationery.

SEE US AT THE METAL SHOW—BOOTH 1501.

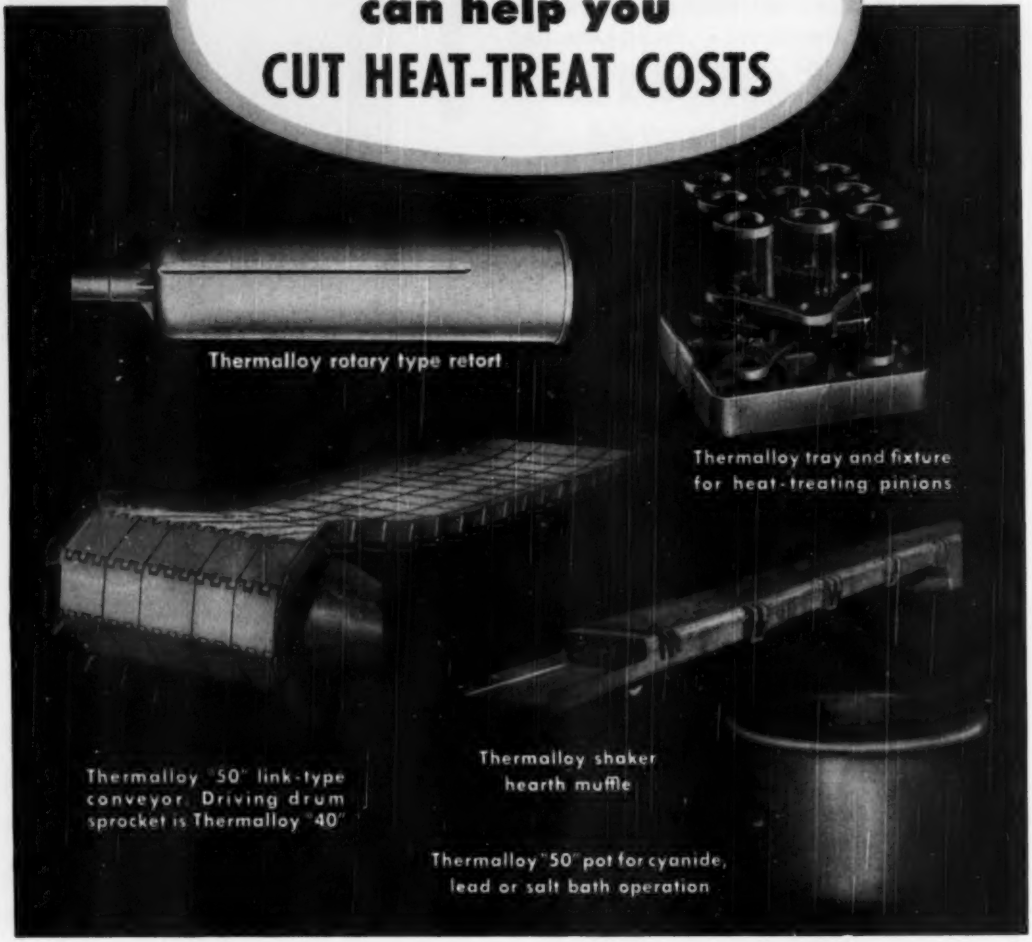
AJAX ELECTRIC SALT BATH FURNACES

SELF-HEATING • SELF-CIRCULATING

AJAX ELECTRIC COMPANY, INC. 910 Frankford Ave., Philadelphia 23, Pa.

The World's Largest Manufacturer of Electric Heat Treating Furnaces Exclusively

THERMALLOY*
can help you
CUT HEAT-TRADE COSTS



Whether it's a standard fixture, tray, retort or muffle . . . or a specially designed unit or part . . . investigate THERMALLOY'S heat and abrasion-resistant properties.

Buying heat-treat equipment is no different from buying any other industrial products from the cost standpoint. Your interest is in "How many cents will it add to the cost of my product?" With THERMALLOY you will get the lowest unit cost per operating hour. For our recommendations call your nearby Electro-Alloys' engineer, or write Electro-Alloys, 1980 Taylor Street, Elyria, Ohio.

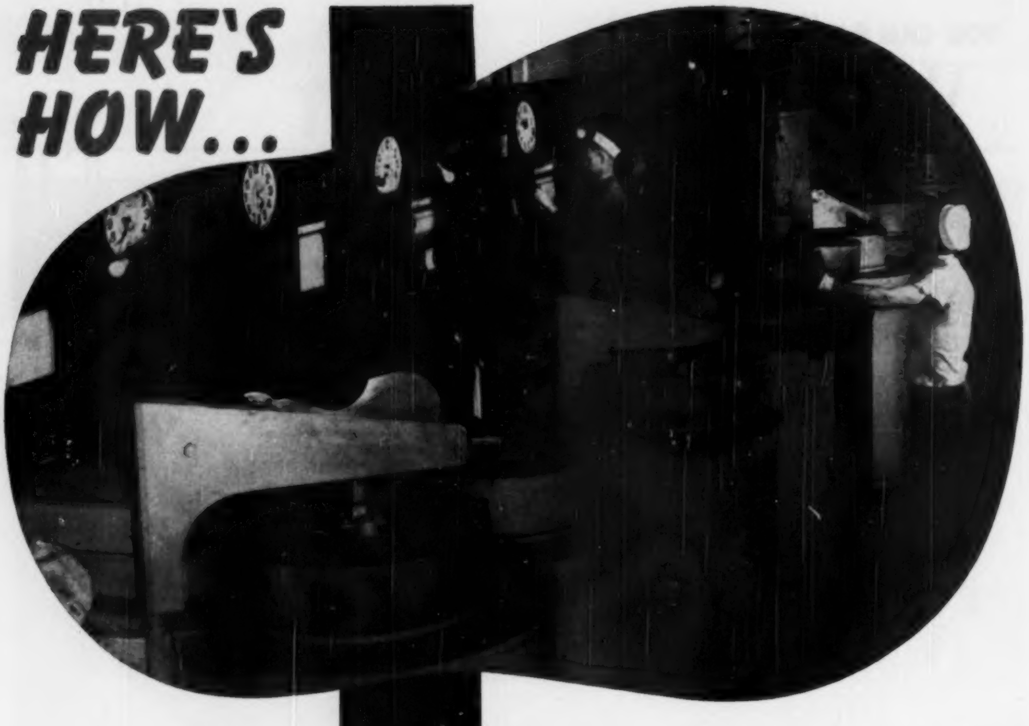
*Reg. U. S. Pat. Off.

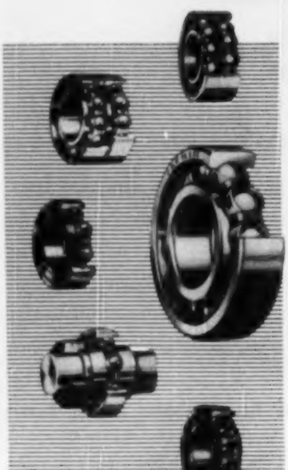
Write for 60-pg. Technical Booklet—Cast 16% Cr.—35% Ni. Alloys

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO

HERE'S HOW...





FAFNIR USES 20 LINDBERG CYCLONES

...to draw thousands of types of bearings!

The Fafnir Bearing Company, New Britain, Conn., uses Lindberg Cyclone Furnaces to draw thousands of types and sizes of its line of ball bearings. They say:

"The metallurgical department of our company entrusts the major part of its drawing operations to Lindberg Cyclone Furnaces because it has found them to be dependable work horses. At the present time there are 20 in use in the Company's three ball bearing plants in New Britain, Conn.

"They have given excellent continuous service for more than 8 years. For long periods they were operated 24 hours a day, seven days a week, (at temperatures ranging from 275 to 1200°F.) without downtime due to furnace failure.

"Because the Fafnir line of ball bearings,comprising thousands of types and sizes, is considered the most complete manufactured in this country, the Lindberg Cyclones draw a considerable variety of parts. The work varies from small to large dense loads (up to 1600 lbs.) of bearing rings, balls and rolls, yet the uniform results demanded for the manufacture of precision products is constantly being achieved—and in an atmosphere of cleanliness and satisfactory working conditions."

Local Offices in every industrial center.

LINDBERG ENGINEERING COMPANY 2448 W. Hubbard Street, Chicago 12, Illinois.

LINDBERG FURNACES

HIGH FREQUENCY INDUCTION FURNACE lined with Norton RM-1169 Magnorite* cement having a maximum use temperature of 3250°F.

LINED TO LAST AT 3250°F

...with Norton MAGNORITE *Cement*

To get more heats out of your high frequency induction furnace linings, try dry-ramming with Norton RM-1169 Magnorite cement. RM-1169 is a result-proved mixture of very coarse electrically fused magnesia grain and enough ceramic binder to give you a dense pack. Maturing at 2100°F, it takes temperatures up to 3250°F in stride. RM-1169 matures in the first heat at the inner edge only. No all-the-way-through cracks to short out your furnace! Easy and inexpensive to install, it also gives you a lining that's easy to patch. It will pay you to make a test run of Norton RM-1169 Magnorite cement next time one of your furnaces needs relining. Order from your nearby Norton refractory distributor. NORTON COMPANY, WORCESTER 6, MASSACHUSETTS.

NORTON

TRADE MARK REG. U. S. PAT. OFF.

Making better products to make other products better

Special REFRACTORIES

Canadian Representative

A. P. GREEN FIRE-BRICK CO., Ltd. TORONTO, ONTARIO

Up-To-The-Minute Facts About Refractory Cements

"The most helpful bulletin on refractory cements ever published"

That's the opinion of the foundry and furnace men who have read this new Norton bulletin. Compiled after exhaustive laboratory and field tests by Norton refractory engineers, this bulletin covers the entire subject of Norton cements with charts, drawings and detailed instructions.

Selection charts

If this bulletin contained nothing but its two selection charts, it would be well worth sending for. At a glance, you know the right cement for various metal-melting furnaces, for brick laying, for resistor imbedding, for burner blocks and tunnels.

"How To" Instructions

Other subjects covered by this booklet include correct preparation, proper installation, drying and maturing . . . all the do's and don'ts that add up to longer-lasting cement applications.

Write for bulletin 863

NORTON COMPANY

321 NEW BOND STREET

WORCESTER 6, MASS.

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

 Published monthly; subscription $7.50 a year in U.S. and Canada (foreign, $10.50); single copies $1.50. Entered as second-class matter, Feb. 7, 1921, at the post office at Cleveland, under the Act of March 3, 1879. *Requests for change in address should include old address of the subscriber; numbers missing due to "change in address" cannot be replaced; claims for undelivered copies must be made within 60 days.*

METAL PROGRESS

The Magazine for Metallurgical Engineers

Vol. 58 *September, 1950* *No. 3*

Table of Contents

Cover design is by Kenneth Carpenter

Technical Articles

Correspondence

Biographical Appreciation

Critical Point, by the Editor

Abstracts

Departments

Nowhere has technical progress been more striking than in some of the metals formerly classed as rare. Most recent of these is vanadium, now bidding for its first serious consideration as a structural material. In discussing the production, fabrication, properties and engineering possibilities of high-purity vanadium, Dr. Kinzel writes with an authority based on his active direction of a major research effort concerning the new metal.

Vanadium Metal—

A New Article of Commerce

IN dramatizing industrial progress, it has been common practice to designate the various periods by the field of activity in which outstanding developments occurred. Thus, we have had The Bronze Age, The Iron Age, and The Steel Age. The last two decades have often been called The Age of Alloys. If this pattern is to continue, one might well predict that the 1950's and 1960's will be known as The Rare Metal Age.

Vanadium is the most recent of the rare metals to become industrially available. It can now be obtained from the Electro Metallurgical Division of Union Carbide and Carbon Corp. in massive form for remelting, as well as in ingots, bars, sheet and foil. The new metal is lighter than iron, has basically good structural properties and resists pitting and corrosion by salt spray and sea water.

Naturally, it is too soon to predict specific applications for pure vanadium, but its properties are such that many uses will undoubtedly develop as the metal becomes better known to the engineering world. For example, parts for use in instrumentation and dynamic loading on shipboard might well benefit by the use of this metal.

What Makes a Metal Rare? Of course, the very term "rare metal" is relative. It takes little imagination to realize that, in times gone by, copper and tin were rare metals; and even iron must have been in this category at one time in history. Aluminum exemplifies the more modern developments; it was almost unobtainable as recently as 1880. Magnesium is another and even more recent case in point. On the other hand, not every uncommon metal is destined for graduation with its class. For instance, consider germanium, which is still classed as a rare metal, even though ways and means of winning it from the ore are well established. It remains in the rare metal category primarily because it does not occur in the earth's crust in concentrations that warrant extraction. It is obvious, therefore, that a metal may be classified as rare for one or two reasons: Either there is no good economical method of producing the metal from the mineral, or its mineral occurrence is insufficient.

The development of vanadium has been stimulated by the recent wholesale search for metals having desired reactions to bombardment with small particles such as neutrons. This has resulted in a concerted effort to produce many of the rarer metallic elements in a pure form and a more-or-

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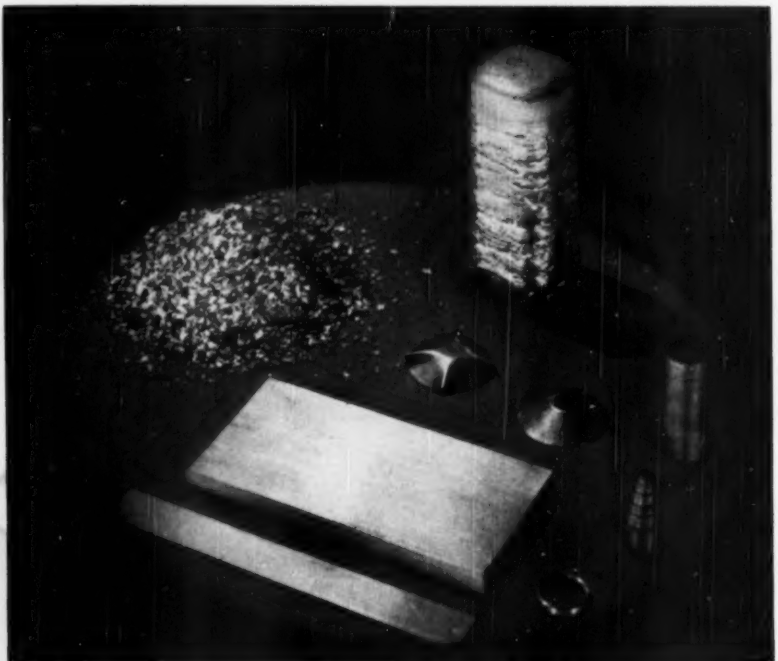


Metallic Vanadium Is Available as Ingots, Plates, Bars, Sheet and Strip, as Well as in the Form of Chips for Remelting. A few fabricated shapes are also shown, including the Belleville-type springs, a conical-helical spring, ring and tube

less ductile state. The beryllium story is well known. While limited in production, beryllium metal is today being used more and more by industry. Columbium and tantalum, too, have been produced in a pure metallic state and are available on the market. Calcium is no longer a rare metal. Much has been written of late about titanium and its potentialities; it is probably the most recent of the rare metals to be industrialized. Zirconium has followed the titanium line and seems likely to join the list of commercially available metals in the not too distant future.

Pure metallic vanadium has been rare, even though alloys of vanadium have been produced in quantity for many decades. Vanadium has been considered a rare metal primarily because it is so difficult to produce in the metallic state without important amounts of alloying additions. The standard article of commerce contains 55% or less of vanadium, although alloys with somewhat higher percentages have been produced.

Vanadium is widely distributed in the earth's crust and its abundance is relatively greater than that of copper, and about equal to that of nickel and zinc. Most soils and rocks contain at least a trace of vanadium, and it is said to be important in the growth of plants. As is true of most minerals, however, there are relatively few deposits in which vanadium exists in sufficiently high concentration to justify mining and recovery for vanadium values alone. The present world production of vanadium comes primarily from deposits in Colorado and adjacent states, from Peru, Northern Rhodesia and Southwest Africa. Among these sources, our own western carnotite ores supply the largest percentage of present production.

It is interesting to note that at various times vanadium has been recovered commercially as a byproduct in a wide variety of minerals and processes. Small quantities have been recovered commercially from phosphate rocks, iron ores, chrome ores, magnetite beach sands, caustic soda solutions used in aluminum refining, soot from smokestacks carrying the fume from certain oils, and ash derived from oil-bearing shales. During the second world war, the Germans went to great lengths to recover vanadium from iron ore, and this was one of the few alloying elements for steel which was not in extremely short supply in Germany during that period. The Colorado carnotites are particularly interesting in that uranium is also present in these minerals, a circumstance that affords additional incentive for winning metallic values from these deposits.

Although the use of vanadium as a ferro-alloy in the manufacture of steels accounts for by far the greatest proportion of the metal produced, it is also used in the oxide form and as ammonium metavanadate in the manufacture of glass and ceramic glazes, as driers in paints and inks, and in fungicides and insecticides.

Discovery of the Element*

In 1801, Humbolt and del Rio of Mexico discovered a new element. They christened it erythronium, but later decided that it was a com-

*The early chemical history of vanadium has been recorded by the late B. D. Saklatwalla in his paper, "The Technical Chemistry of Vanadium", *Industrial and Engineering Chemistry*, Vol. 14, 1922, p. 968. A more recent summary is "Vanadium and Its Alloys — A Review of Previous Work", *Journal*, Iron and Steel Institute (London), February 1950.

pound of chromium. This is generally considered to be unfortunate because they undoubtedly did have vanadium. Their failure to identify vanadium set its chemistry back some 30 years. Many of us, however, feel that this is not so unfortunate as it might seem because those 30 years have long since been recouped and happily we are not now faced with the need for pronouncing the chemical tongue-twister by which this metal was originally known.

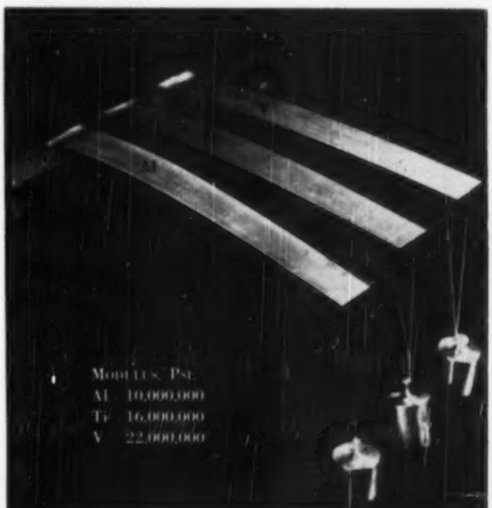
It was not until 1830 that Sefström, in Sweden, positively identified the new element. He christened it vanadium, from Vanadis, the nickname given to Freya, the Scandinavian goddess of love. In the past few years, sufficient love has been brought into the preparation of pure vanadium to justify its name. By 1870, Roscoe isolated a small amount of vanadium in impure form and obtained considerable physical and chemical data concerning the element. From then on, the work dealt largely with the alloys of vanadium and its effects in steel and the abundant nonferrous metals.

Production of Ductile Vanadium*

It was not until 1927 that metallic vanadium was again given attention, when J. W. Marden and M. N. Rich, in line with their other systematic experiments on pure metals, produced ductile vanadium. To do this, they reacted vanadium pentoxide with calcium in the presence of calcium chloride. The small fused globules so produced were worked into short lengths of wire, and certain physical and chemical properties were determined, but according to Marden they could not do it again! For many years, these small bits of wire were the only pieces of ductile vanadium in existence, and the physical constants available on pure vanadium were obtained from these meager samples.

With the recent urge toward finding materials having good physical and chemical properties, and the search for different reactions to neutrons and the like, there have been a great many attempts to produce ductile vanadium. E. D. Gregory has produced such metal by reacting the trioxide with calcium in the presence of calcium chloride. He obtained the trioxide by hydrogen reduction of the pentoxide. Using this material at 100 mesh size, mixed with calcium chips and calcium chloride, he heated it in an iron cup in an argon atmosphere and leached the resultant product. The final product was a powder that could be handled by the usual techniques of powder metallurgy, using all the precautions necessary for a metal that reacts readily with oxygen and nitrogen and absorbs hydrogen. R. K. McKechnie and A. U. Seybolt produced vanadium metal by the same general reaction; using iodine to improve the energy relationships, they obtained a 53% yield. In processes of the type cited above, the essential feature is to organize and control the reaction so that oxygen and nitrogen are held to reasonably low levels. McKechnie and Seybolt report that oxygen greater than 0.07% and nitrogen greater than 0.028% may cause brittleness.

E. A. Gulbransen and K. F. Andrew report that at 750° F. vanadium reacts with oxygen more readily than does titanium, but less rapidly than tantalum, zirconium or columbium. The rate of oxidation increases rapidly with temperature. At 1300° F. and higher, according to the same investigators, vanadium reacts with nitrogen more readily than either of the four metals mentioned above. The nitride is highly stable even in a high



A Rigidity Comparison Among Aluminum, Titanium and Vanadium Shows a Comparatively Small Deflection for the Vanadium Beam

*The first description of ductile vanadium is the article "Vanadium", by J. W. Marden and M. N. Rich, *Industrial and Engineering Chemistry*, Vol. 19, 1927, p. 786. Recent developments were reported as part of a symposium on rare metals, at the Cleveland meeting of the Electrochemical Society, April 1950: "Preparation of Ductile Vanadium by Calcium Reduction of Vanadium Trioxide", by E. D. Gregory; "Preparation of Ductile Vanadium by Calcium Reduction", by R. K. McKechnie and A. U. Seybolt; and "A Preliminary Study of the Reactions of Vanadium With Oxygen and Nitrogen", by E. A. Gulbransen and K. F. Andrew.

vacuum, and both the oxide and nitride phases are soluble in the metal itself.

Union Carbide Research

At the Electro Metallurgical Div. Research Laboratories in Niagara Falls, N. Y., major effort has been expended on the development of a process for producing ductile vanadium that can be adapted to operation on a reasonably large scale and that will give a product of quality sufficient for ready fabrication — all aimed at an ultimately acceptable economy in use. Obviously, discovery of processes, research necessary to their development, and the bringing of the production of vanadium metal to an industrial stage are the result of cooperative effort on the part of the entire staff of the Laboratories, and specific citation of particular contributions is more than difficult. However, Messrs. G. D. Bagley, H. deW. Erasmus, W. J. Bohnet, W. O. Binder and C. M. Brown have been primarily concerned with some of the more difficult aspects.

The research people started with basic information on the reduction of vanadium oxides and applied the techniques that had been developed through the years in the laboratories as well as the plants of the Electro Metallurgical Division and U. S. Vanadium Corp. Ductile vanadium metal has been consistently produced within the following chemical limits:

Oxygen	0.05 to 0.12%
Hydrogen	0.001 to 0.004
Nitrogen	0.02 to 0.04
Carbon	0.03 to 0.07
Vanadium	99.9 to 99.8

Within these limits, yields have been consistently greater than 90% and the metal produced is suitable for either working or remelting as required.

The product is essentially a solid mass of crystalline vanadium and has been termed "massive vanadium" to differentiate it from ingot metal. The size of units in which the process has been carried out and the scale of operation have been progressively increased, and at present there is no practical limit to this scale within probable demands. The purity of the metal, too, has been progressively improved. It is to be expected that this trend will continue with increased demand and further experience. Although it is hazardous to predict demand, our present production facilities are such that, as far as massive vanadium metal is concerned, any reasonable demand in the future can be met. Present production is geared so that, on reasonable notice, 100 lb. of massive ductile vanadium per day can be delivered. The metal would be suitable for working into small articles or it could be remelted into ingots suitable for working into larger articles.

This Macrograph of a Small Cross-Sectioned Vanadium Ingot Shows a Uniform Longitudinal Grain, Especially Suited for Rolling and Forging. Section shown is 6 x 2⅜ In.

The present cost of ductile vanadium in massive form is approximately ten times that of the vanadium contained in standard ferrovanadium. The pure massive vanadium sells for about $30 per lb. in the limited quantities produced. Production on a 100-lb.-per-day basis would materially reduce the cost.

Working massive vanadium into small shapes presents no serious technical problem, but would be uneconomical. Massive vanadium may be remelted by using a tungsten arc in an argon atmosphere and a water-cooled copper mold. This process and its techniques do not differ much from those now used industrially for molybdenum and certain other metals, with which the process has been proved commercially practicable. However, other means of producing large vanadium ingots suitable for working into ductile vanadium bar, sheet and foil are now under investigation. These are sufficiently promising so that as yet it has not been felt advisable to install remelting equipment to match the production capacity for massive vanadium. In an emergency, this could be done on short notice.

Present Fabricating Techniques

The massive vanadium or the argon-arc-melted ingot may be hot worked with or without protective sheaths. Surfaces of unsheathed masses or ingots are conditioned by machining or grinding before working. Rolling or extrusion without sheathing requires a protective atmosphere which, in itself, involves special precautions and special techniques. These have been developed, but they are commercially justified only when sufficiently large quantities of material are involved; sheathing is recommended for small-scale industrial operations. The sheathing technique does not differ from that normally used for other reactive metals. Although iron or steel may be used for the sheath, stainless steel is the preferred material because its hot rolling characteristics more nearly match those of the vanadium. Any of the common austenitic grades of stainless steel may be used. The sheath is fabricated by Heliarc welding pieces of stainless steel, generally about ⅛ in. thick, so as to make a tight-fitting box around the ingot. Once the ingot is sheathed, no further special precautions are necessary, although extra time is allowed for heating in order to insure uniform temperature within the sheath.

Ingots of Vanadium Are Readily Hot Forged Into Billets to Prepare Them for Rolling

Breakdown — Optimum initial breakdown temperature is 2000 to 2100° F. Once the ingot has been broken down, the hot working temperature may vary from 1475 to 2100° F. without imposing a penalty. In general, rolling practice with respect to passes and reduction follows that established for austenitic stainless steels. However, it is interesting to note that rolling may be carried on continuously at temperatures well below the 1475° F. specified above, and although this may be thought of as cold rolling, particularly when temperatures of about 575° F. are reached, the metal does not work harden appreciably. Thus, there is no discontinuity in effect between hot and cold rolling. Consequently, on final heating and rolling, rolling may be continued right down to room temperature. For various practical reasons, 1300 to 1100° F. is a good finishing range. After rolling, the sheath is removed by slitting and peeling. To make sure that no iron or other elements of the sheath are present in the outer part of the final vanadium article, it is common to remove about $\frac{1}{16}$ in. from the surface of the rolled product. However, the necessity for removing surface metal will vary with time and temperature of heating and size of the article, and it is a function of the total diffusion during the hot working.

Sheet Rolling — In making sheet or foil, it is common to hot work down to approximately ¼ in. thickness. This is followed by cold rolling to produce the final article. Vacuum or inert-gas annealing at 1650° F. for 1 hr. puts the hot worked material into condition for subsequent cold rolling. As a rule-of-thumb check, it has been

This Strip of Vanadium, Cold Rolled to 0.020-In. Thickness, Is Ready for Fabrication Into Springs and Other Parts Requiring High Dynamic Stress

found that the hardness of the surface to be cold worked should be less than Rockwell B-85. Hardness greater than this after annealing indicates insufficient surface removal of the diffused material. As mentioned above, vanadium does not work harden appreciably even during cold working, so that cold working techniques are not critical. A total reduction of 85% can be made without intermediate annealing, but in so doing the hardness may reach Rockwell B-90 to 100, depending on the section involved. When the surface hardness exceeds Rockwell B-95, edge-cracking may occur. Again, this will depend on size and shape of section and prior condition.

There seems to be a curious phenomenon in connection with vanadium, as yet unexplained. In the fully annealed or hot rolled state, sections ¼ in. or greater in thickness are relatively brittle. They are not so brittle that they cannot be cold rolled, and if they are cold rolled even to a moderate degree, the apparent brittleness disappears. The material may then be drastically cold worked, bent or formed as required — all this in the cold rolled condition. This behavior may be related to the increase in malleability on heating from room temperature to about 575° F.

Since oxidation of the vanadium does not take place below 575° F., there is something to be gained by cold rolling the metal between 400 and 600° F. However, for convenience, simple bar and sheet are normally cold rolled at room temperature.

Machinability of pure vanadium appears to be about the equivalent of cold rolled steel. The metal has been found free-cutting, and tools such as those used for copper with a high rake angle of about 15° and a sufficient clearance angle of 7 to 15° have been successful. To produce a good surface finish, high cutting speeds and light cuts can be employed. A light lubricant, such as kerosene, improves the quality of the machined surface and permits higher cutting speeds. Vanadium is easier to machine than Monel, nickel, stainless steel and titanium, and not quite so easy as copper, yellow brass or aluminum.

Forming — Since it has good workability at mildly elevated temperatures, vanadium may be bent, stamped and pressed in the usual manner. The Belleville spring shown in one of the accompanying illustrations was made in a simple lead-lined die. Rubber plungers may also be used.

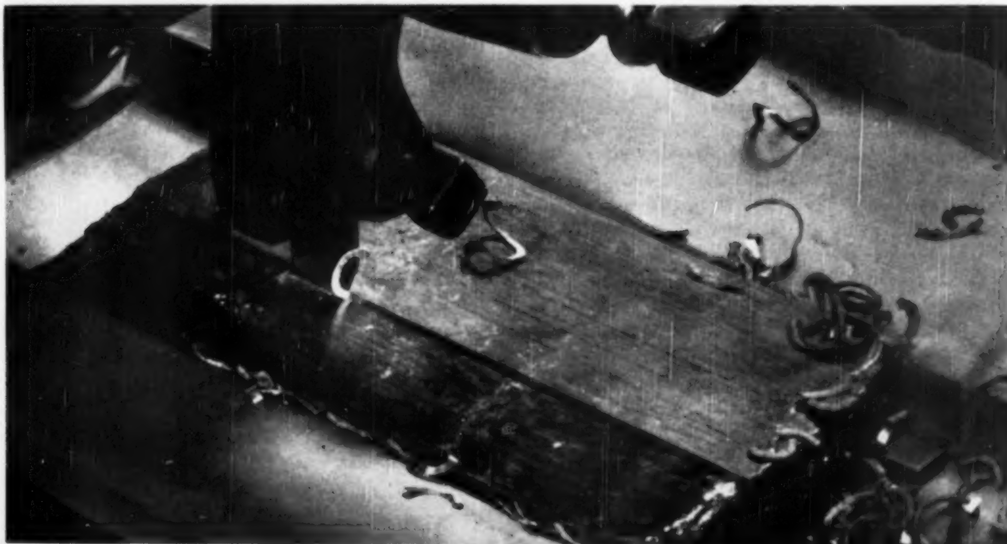
Welding — Ductile vanadium may be welded with argon shielding and a Heliarc torch. It has smooth welding characteristics. In this application, it is essential that adequate flow of argon be maintained for optimum shielding. For optimum purity, the metal should be welded in a special apparatus providing an argon atmosphere. As vanadium does not transform, annealing after welding is unnecessary. However, stress relieving at about 1100° F. in an inert atmosphere may be used to insure dimensional stability.

Metallography

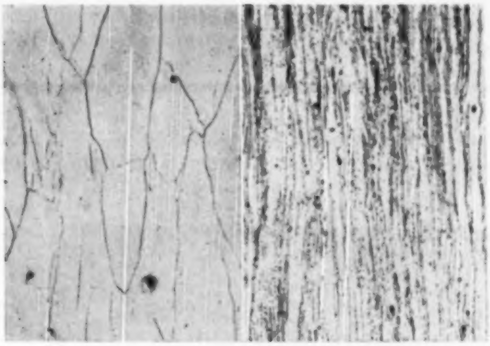
Preparation of metallographic samples of vanadium metal involves the usual mechanical polishing techniques. Minor modifications, such as the use of wax or wax and graphite on the abrasive papers, are helpful. Finishing is done on broadcloth with Linde alumina Type A-5175 and finally Linde alumina Type B-5125 as abrasives. As it is difficult to eliminate disturbed metal from the polished surface, repolishing after etching is necessary to bring out the true structure.

Because mechanical polishing has been found very time-consuming, electropolishing in a solu-

Slabs of Vanadium Are Easily Machined to Make Plates of Standard Dimension With a Good Surface Finish



Hot Rolled; 250 × Cold Rolled 45%; 100 ×



Vanadium. Electropolished; etched in $NH_4OH + H_2O_2$

tion of glacial acetic acid with 5 to 10% perchloric acid has been used. The current density is 1 to 1.5 amp. per sq.in. Samples are rough-ground through No. 120 abrasive and electropolished for 1 to 2 min. A second polishing period of about the same duration in a fresh solution frequently is helpful. As with other metals, electropolishing frequently produces pits, and this seems to be aggravated in the case of vanadium. The pits shown in the accompanying micrograph of hot rolled vanadium are illustrative.

Most satisfactory results in etching vanadium metal have been obtained with either concentrated ammonium hydroxide containing 5 to 10% H_2O_2 or 10% sodium carbonate solution used electrolytically. Both of these etchants delineate the structure of vanadium and bring out any precipitated carbide or nitride phase.

Physical and Chemical Properties

The physical and chemical properties of vanadium metal probably vary appreciably with the oxygen, nitrogen and carbon contents, as well as with the amount of cold working. Hardness varies from Rockwell B-75 to C-29 and can be fairly well controlled within these limits. Thus, the point of interest is not strength alone, but relative strength and ductility. From the numbers recorded in the data sheet on p. 344-B, it can be seen that the strength-ductility relation is not out of line with what would be expected. The relatively low elongation figure must be viewed in the light of the small change with cold working, a unique situation.

The density of vanadium is appreciably lower than that of steel, and the elastic modulus is relatively high for that density. The modulus-density ratios for steel and vanadium are practically equivalent (3.7 million), and higher than that for titanium, which is variously given as 3.1 to 3.6 million. From this comparison it is apparent that, other things being equal, vanadium would be the first choice for a structural part in which flexural rigidity was the determining factor. It is also apparent from this and the figures for static tensile properties that vanadium should make a good spring material.

Some of the other properties of vanadium are of interest and are indicated in the tabulation on p. 344-B. Data on the chemical resistance of vanadium are open to some question because early work was based on samples of unknown and low purity. The more recent work shows that, although vanadium is highly resistant to reducing acids in moderate concentrations, it is not resistant to oxidizing acids. Alloys of vanadium and chromium have been prepared, and the resistance of vanadium-base alloys containing chromium to oxidizing mediums is appreciably increased. However, even these alloys are far from platinum in corrosion resistance. Broadly, it could be said that for use in a reducing medium, vanadium is the equivalent of Hastelloy C, and one of the most interesting sets of specific results obtained thus far shows that vanadium is resistant to pitting and corrosion by sea water and salt spray. This resistance, combined with its high elastic modulus and negligible magnetic susceptibility, might well lead to interesting applications in instruments and parts for dynamic stress on board ship or in salt water atmospheres. This type of application is only one of many that may develop for the metal in the future.

Conclusion

In introducing a new metal, it is common to predict that it will be the base of a new industry; that it will threaten to replace, if not common steel, at least the stainless steels; that it will solve practically all of the unsolved problems in the design engineer's book; and that the real metallurgical revolution is here. No such claims are made for ductile vanadium. Let the simple statement suffice that it is in production and will make its own future.

Because it is so new, there has as yet been no opportunity to fit metallic vanadium into the engineering world, but the history of every newly commercialized metal is that as long as it has the two prime requisites for a material of construction — namely, reasonable mechanical and chemical stability — there will always be one or more applications that are uniquely fitted by the new combination of properties.

In an age of specialized alloys and rare metals, it is well to be reminded that some metallurgical knowledge antedates the present century or even millennium. The objects described by Dr. Anastasiadis were fabricated more than 2000 years ago.

Bronze Welding, Riveting and Wiremaking by the Ancient Greeks

IT IS IMPOSSIBLE to know accurately the age when copper was melted for the first time and when articles of copper originally appeared. However, it seems certain that copper was used about 5000 years ago. Undoubtedly, copper and bronze manufacturing flourished in Greece, in the islands of the Aegean Sea, and along the Mediterranean coast of Asia; this may be seen in the marvelous monuments excavated in these regions or pulled up from the bottom of the sea nearby. Such work could have been done only by men who had great skill in casting copper and bronze.

The ancient Greeks had intimate metallurgical knowledge, not only in preparing pure metals by the primitive technical means at their disposal, but also in appreciating the advantages and limitations of the metals they worked with. Furthermore, they had learned to discriminate among the properties of various metals and alloys, using for each article different proportions of the alloying metals, according to the intended purpose.

Unfortunately, the old scripts contain very little about metallurgy and metalworking. Persons conversant in the art jealously kept the secrets of their achievements, except perhaps to share them with members of their family. From the metal objects found in modern times, however, we can now deduce some of the technical secrets that were used by those ancient and mystic metalmasters. As far as I know, no investigation has been made previously about the welding, riveting and wiremaking carried out by the ancient Greeks.

A beautiful bronze race horse with a jockey (Fig. 1), natural size, is a part of the rich collection of the Archaeological Museum of Athens. It was found in 1929 by fishermen, on the bottom of the sea near Artemisium Cape on the north side of Euboea Island. It seems to belong to the Hellenistic period, around 350 B.C.

The horse was hollow-cast with a wall thickness of about 2 mm. (0.08 in.), and its several parts were welded together. The weld zones are not easily visible because the patina covered the whole body of the horse and the welds were flat and even. With great care and without destroying the appearance of the horse's body, I selected a small piece of the weld zone in order to determine the chemical composition of the bulk metal, as well as of the deposited metal, and to examine the weld zone microscopically.* Percentage compositions were:

	Cu	Sn	Pb	Fe	Zn
Bronze horse	86.452	12.762	0.035	0.05	0.58
Weld metal	87.350	10.919	0.107	0.352	1.003

Such bronze alloys with small amounts of lead, iron and zinc are found among the commercial

*The samples used were collected with the permission and valuable assistance of Mr. Panagiotakis, director of the Museum, to whom I wish to express my thanks. Credit is also due to I. Mitsios and A. Charchalakis for the chemical analyses.

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bronzes today. Considering the primitive means that the ancient Greeks used for producing their metals, these bronzes are very pure indeed. However, the small percentages of the accompanying metals — particularly zinc — have favorable effects on the durability of the alloy. They also eliminate gas holes in the metal and facilitate filling the molds exactly. Of course, it is difficult to decide whether such accompanying metals were added to the bronze intentionally or are present as impurities.

The ancient Greeks knew how to produce bronzes even purer than the one mentioned above. In the "Muspratts Chemie", 1893, Vol. 4, p. 2082, we find analyses of ancient bronzes, among which are some containing 88.9% copper and 11% tin (99.9% purity) or 86.8% copper, 13% tin (99.8%).

Examined microscopically, all broken parts of the horse's body were quite free from gas holes and slag inclusions, which means that the metal was melted quickly and protected against the action of air, perhaps by a layer of charcoal.

Figure 2 shows the complete penetration of the deposited metal into the joined pieces. Fusion of this kind surely indicates that the surrounding metal was preheated. As shown by the above analyses, the difference in the composition of the weld metal and the cast bronze is insignificant. One may surmise that the welding was done either by preheating the edges of the pieces to be joined and pouring the molten weld metal on the welding zone, or by laying a piece of the weld metal on the edges to be joined and heating them together, with a blowpipe, until weld metal and pieces became fused. In many places underneath the weld zone, some metal is seen which flowed through during the welding.

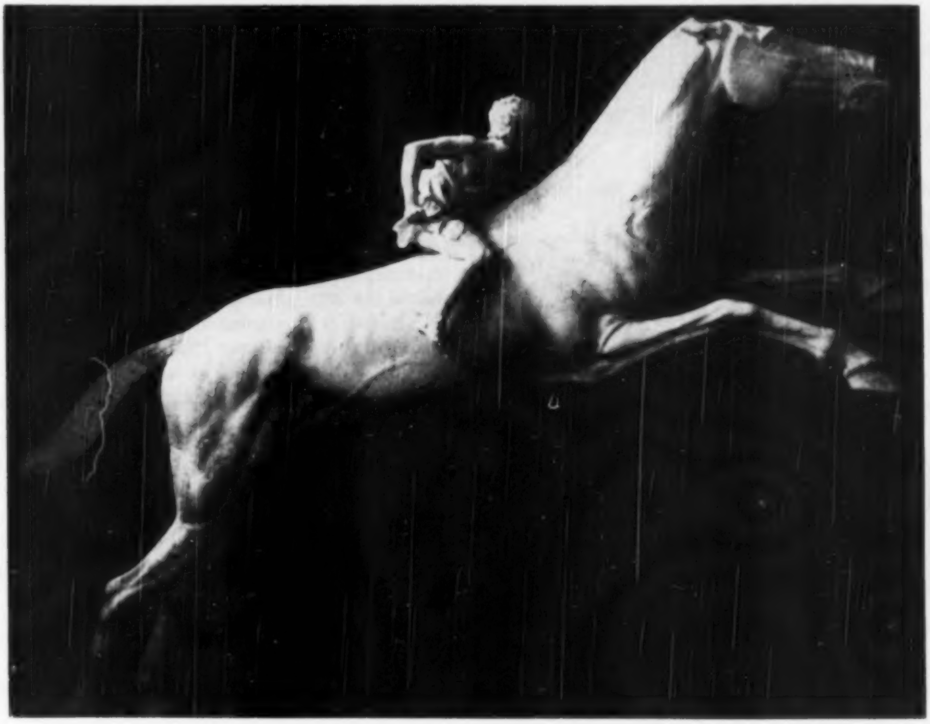


Fig. 1 — Bronze Race Horse (About 350 B.C.) From the Archaeological Museum of Athens

Figure 3 shows a copper piece welded with bronze containing a small amount of tin (3.2%). The ancient artisans must have found difficulties in welding copper with copper and used bronze instead because of experience which taught them that tin lowers the melting point of the copper, making the bronze easier to work with. For this piece they probably used bronze with only a small

Fig. 2 — Penetration of Deposited Weld Metal (Bottom). The bronze pieces that were welded contain 86.5% copper and 12.8% tin; the weld metal, 87.4% copper and 10.9% tin

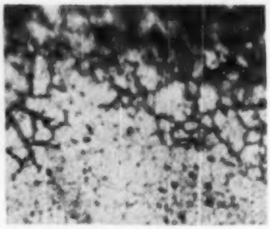
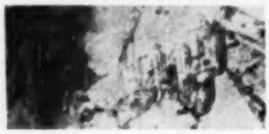


Fig. 3 — Copper Piece (Left) Was Welded With a Bronze Containing a Small Amount of Tin (3.2%)



amount of tin in order to minimize the difference in color.

A piece of copper was examined that had been joined with a copper rivet which, when analyzed, was found to contain 98.1% copper. Bronze pieces were joined with rivets of bronze. Generally, all the different kinds of faults or holes in their castings were repaired by using the same metal as that of the casting. This may have been done simply to get uniform appearance of the riveted objects, or the artisans may have realized the importance of this kind of riveting from the point of view of corrosion. Of course, pieces of bronze joined with copper rivets have been found but these objects are of secondary importance.

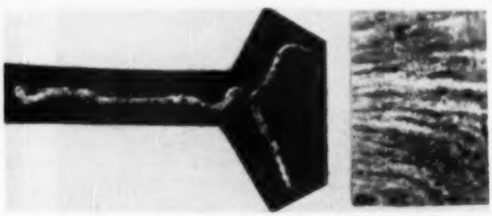


Fig. 4 — Copper Wire. Note elongation of grains

Figure 4 shows a copper wire of 4-mm. (0.16 in.) diameter which formed a decoration on a beautiful copper cup. Microscopic examination shows elongated crystals following the direction of working (Fig. 4, right). The appearance of the elongated grains indicates that the wire was made by drawing.

From the above observations, it may be concluded that the ancient Greeks had a surprisingly good practical knowledge of bronze welding, riveting and wiremaking.

Metal Production in Korea

A NOTE on the mineral wealth and metal production in Korea should be interesting at this juncture. Accurate data are available only for the region south of the 38th parallel, where the only operable metallurgical works is a copper smelter of 10,000 tons annual capacity on the south coast, some 75 miles west of Pusan. In past years, this plant operated on mixtures of gold and copper ores, primarily to recover gold, but operation had to be curtailed or suspended when the country was divided, for lack of suitable sulphide copper ore below the 38th parallel.

Numerous tungsten deposits occur across the peninsula at about the 37th parallel, one of the world's largest deposits of scheelite being worked at Sangdong. Korea's annual production of tungsten concentrate increased almost 100-fold with Japan's demand for tungsten between 1933 and 1944. Since 1940, the Sangdong deposit has yielded 850,000 metric tons of ore, from which were recovered concentrates containing 7523 tons of WO_3. This is equivalent to about 70% of South Korea's total output. They exported 1870 tons of 60% tungsten concentrates to the U.S.A. in 1948.

Important deposits of amorphous graphite occur in the central region of South Korea, from which about 40,000 tons were shipped in 1949.

North Korea is much more highly industrialized — or was at the end of World War II. While no information is available since Russian occupation, it is known from wartime Japanese documents that three small copper smelters, two zinc smelters and two lead smelters were in operation with total capacity of about 17,500 tons per year of each metal. The Japanese had also constructed three aluminum-reduction plants (with associated alumina refineries) in coastal cities with combined capacity of 34,000 short tons of metal a year and had two others under construction which would bring the entire country to the sizable total annual capacity of nearly 100,000 tons. Magnesium production capacity equal to 7500 tons annually was also in existence. Blast furnaces and a small steel plant were in operation near the Northern capital, Pyengyang, operating on a high-grade iron ore mined in the vicinity.

Low-alloy steels properly austempered are essentially bainite in microstructure and martensitic after martempering and tempering or oil quenching and tempering. These two structures are substantially equivalent in mechanical properties at the same hardness.

Three Low-Alloy Steels, Austempered Versus Oil Quenched

AUSTEMPERED high carbon steel has been shown by several investigators to be superior in several respects to the same steel heat treated by the conventional method of quenching and tempering.[1] (For references, see p. 390.) In particular, austempering results in greater ductility at relatively high hardness; moreover, austempering is less likely to cause severe distortion or cracking than a quench in water, oil or brine. However, one limitation, as applied to carbon steels, is that it can be used only on relatively thin pieces because of the low hardenability of such steels. If the section size is too large, austenite transforms partially (or completely) during cooling to the temperature of the austempering bath rather than *at* the desired temperature, so that less favorable properties result.

As most alloy additions increase the hardenability of steel, it is natural that alloy steels should be used if parts to be austempered are too large in section to be heat treated by this method when made from carbon steel. The properties of austempered alloy steels are, therefore, of considerable interest, even though austempering may be adopted for reasons other than to improve mechanical properties.[2]

To obtain information on such properties three commercial low-alloy steels, 2335, 6150 and 4063 (Table I), were austenitized 15 min. after reaching heat in a furnace with slightly decarburizing atmosphere and then austempered in a relatively large salt bath. Other samples were also quenched in oil at room temperature and tempered immediately in a salt bath. Each steel produced samples at three different hardness levels by both heat treatments. (Schedules are given in Table II.) For the two higher-carbon steels, the hardness range was approximately C-45 to 55, whereas for 2335 it was about C-40 to 50. In each instance, the highest hardness was obtained by austempering at a temperature near, or somewhat below, the calculated temperature where martensite starts to form (the M_s point[3]), and the lowest hardness was secured by austempering not more than 180° F. above the M_s point. Oil quenched specimens were tempered to match the hardness obtained by austempering.

The measurements included tensile tests, rotating beam fatigue tests of polished specimens and Charpy keyhole-notch impact tests at 75, 0 and

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−50° F. The tensile and fatigue specimens, slightly oversize as heat treated, were ground to finished dimensions (0.505 and 0.200-in. diameter, respectively) to remove any decarburized metal. Impact specimens were finished 0.394-in. square to final size and the notch tightly plugged with asbestos before heat treatment.

Results of the above tests are presented in Fig. 1 and 2. In these charts, open symbols are used to denote quenched and tempered specimens, whereas blackened symbols are for corresponding austempered specimens. Except in the fatigue data in Fig. 1, each plotted point represents the average of two to four tensile tests or three notch-impact tests. Bands enclosing most (or all) of the plotted points are drawn to indicate the range of experimental observations. It is not implied that these bands represent the true relationship of the variables, nor the maximum spread to be expected if a much larger number of tests were made; they do serve, however, to indicate the general trends and the variation to be found even in carefully conducted tests of a small number of steels.

Table I — Data on the Steels*

	2335†	6150	4063
Carbon	0.37	0.54	0.64
Manganese	0.68	0.82	0.94
Phosphorus‡	0.014	0.016	0.011
Sulphur‡	0.021	0.025	0.016
Silicon	0.21	0.26	0.23
Nickel	3.41	—	—
Chromium	—	0.95	—
Molybdenum	—	—	0.28
Vanadium	—	0.15	—
Calculated M_s	595° F.	525° F.	505° F.
Austenitized at	1475° F.	1600° F.	1500° F.
Austenite grain size	7 to 8	9	6 to 7

*Blank spaces denote "not determined".
†Referred to in Fig. 1 to 3 as 2340.
‡Heat analyses.

Tensile and Yield Strength — Over the range investigated, tensile strength is approximately proportional to hardness, with no consistent difference in strength between austempered and quenched and tempered specimens, as is evident from Fig. 1. A similar relationship between the hardness and the tensile strength of quenched and tempered steels has been presented by Patton, by Janitzky and Baeyertz, and by others.[4]

Yield strength also varies almost linearly with hardness over the range covered in this investigation. Unlike tensile strength, however, the yield strength of these alloy steels tends to be lower after austempering than after quenching and tempering. (This is also true of carbon steel.) With few exceptions, points representing austempered specimens lie below the dashed line in the second band from top of Fig. 1, whereas those representing quenched and tempered specimens lie above it. This difference is reflected in the ratio of yield to tensile strength after the two methods of heat treatment, the ratio being lower after austempering. The yield-tensile ratio tends to decrease as hardness increases — at least for quenched and tempered specimens.

Ductility — Reduction of area decreases for both austempered and quenched-tempered specimens, shown in the next to bottom band in Fig. 1, and the amount of scatter becomes greater as hardness increases. There is little over-all difference in ductility as a result of the two methods of heat treatment, although nearly all of the points representing austempered specimens lie above the corresponding points representing quenched and tempered specimens. Thus, although austempering may increase reduction of area slightly in individual cases, the increase is not great enough to raise the general level appreciably.

Table II — Heat Treatments After Austenitizing

Steel Grade	Austemper		Quench & Temper	
	Time and Temperature	Hardness	Tempered	Hardness
2335	2 hr. at 500°F.*	C-49.5-50	1 hr. at 495° F.	C-49.5-50
	1 hr. at 565	47	1 hr. at 600	46.5-47
	45 min. at 630	41-42	1 hr. at 715	41.5-42
6150	4 hr. at 460° F.*	55-56	1 hr. at 450° F.	55.5-56.5
	2 hr. at 585	50-52	1 hr. at 690	49.5-52
	1 hr. at 630	46-48	1 hr. at 830	46.5-48
4063	1.5 hr. at 530° F.	54.5-55.5	1 hr. at 595° F.	53.5-54.5
	30 min. at 605	49-50.5	1 hr. at 745	49-50
	20 min. at 685	44-45	1 hr. at 875	44.5-45.5

*This temperature is below M_s, and the specimen's microstructure contained some martensite.

Elongation decreases consistently with increased hardness, with no apparent difference between the two methods of heat treatment.

Fatigue — Endurance limit of polished specimens increases with increasing hardness, as shown in the central band of Fig. 1. If the ratio of endurance limit to tensile strength of each steel in each heat treatment is computed and this ratio *R* is plotted against Rockwell hardness, a rather wide band results, descending toward higher hardness;

values range linearly from $R = 62\% \pm 4$ at C-42 down to $R = 43\% \pm 5$ at C-55. Little or no over-all improvement is evident in either the endurance limit or the ratio R as a result of austempering, when considering the group of tests as a whole. Examination of the results of individual pairs of tests reveals that in nearly every instance austempering gave a slightly higher endurance limit and ratio R; however, these differences due to method of heat treatment are less than the over-all scatter in results due to other causes.

Notch Toughness — In general, notch toughness is slightly greater at all temperatures after austempering than after quenching and tempering, as shown in Fig. 2, although results for the two heat treatments are pretty well mixed up in the band plotted for −50° F. As expected, increasing the hardness decreased the notch toughness.

Transition Temperature

To determine whether the notch-impact "transition temperature" for an austempered steel differs from that resulting from the use of other methods of hardening, Charpy keyhole-notch specimens of the three steels were heat treated as described in Table III, and were then tested in impact while at temperatures in the range −315 to +500° F. Test specimens of each steel were first austenitized at temperatures shown in the next-to-last line of Table I (after packing in cast-iron chips in a closed container) and were then austempered by transferring them into a salt bath at temperatures and for times shown in Table III; the temperatures were 25 to 60° F. above the calculated M_s point. Corresponding specimens were also quenched and then tempered for 1 hr., or

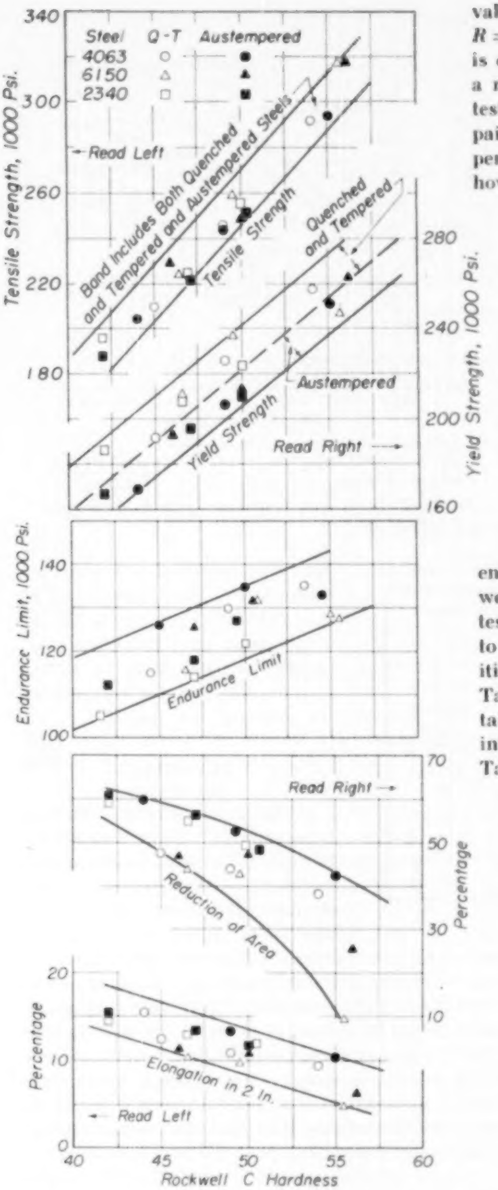


Fig. 1 — Except for Yield Strength, There Is no Consistent Difference Between Tensile and Endurance Properties of Three Low-Alloy Steels, Austempered Versus Quenched and Tempered to Various Hardnesses

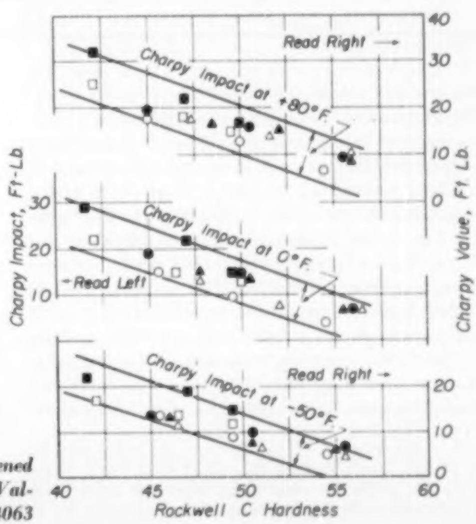


Fig. 2 (Right) — Austempered Specimens (Blackened Symbols) Tend Toward the High Side of Charpy Values Versus Hardness Bands for 2335, 6150 and 4063

martempered and tempered (1 hr.) to the same hardness as resulted from austempering.

Two variations of the martempering treatment were used. In one, the steel was quenched into a salt bath at 400° F., which is well below the calculated M_s temperature, held there for 1 min. and cooled in air. The second method differed only in that the salt bath was at the same temperature as used for austempering (25 to 60° F. *above* the calculated M_s), and subsequently double tempered. The difference between austempering and this latter method of martempering was in the time the specimen was held in the bath; in austempering, this time was long enough (45 to 120 min.) to permit essentially complete transformation of austenite; in martempering it was only long enough (1 min.) to insure that the specimen reached the temperature of the bath before removal.

Little, if any, high-temperature transformation to fine pearlite occurred in the heat treatment of these steels. The microstructure of the austempered specimens was essentially all bainite. The structure of the quenched-and-tempered specimens was tempered martensite, as was that of the martempered-and-tempered specimens, with the possible exception of a slight amount of tempered bainite* in some.

Curves relating notch toughness to test temperature, Fig. 3 and 4, above and at right, show no sharp transition for any of the treatments. At the highest test temperatures, austempered specimens absorbed more energy than the others, but little difference was found at zero and −100° F. for 6150 and 4063. Martempering resulted in no improvement over quenching and tempering, the curve for martempered specimens being usually lower even than for quenched and tempered specimens. Martempering by quenching initially to the M_s temperature gave about the same results as quenching to 400° F. (below M_s) and for this reason the data are not included.

*A small amount of bainite may have formed in some of the steels during the short time they were held in the martempering bath, although none was detectable after subsequent tempering.

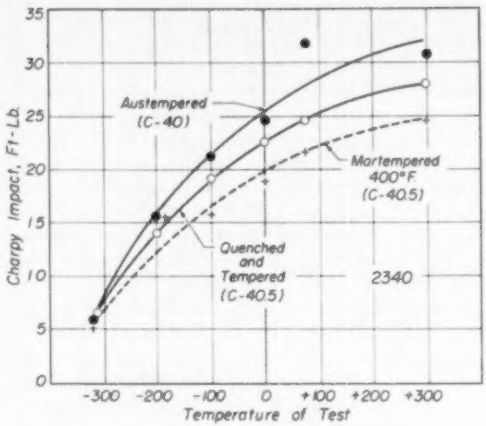


Fig. 3 — Austempering Gives Consistently Higher Charpy Values for 2335 Steel, Hardened to Rockwell C-40, and Tested at −200° F. or Higher

Table III — Heat Treatment of Charpy Specimens for Fig. 3 and 4

Steel	Treatment	Quench	Tempering	Hardness
2335	Quench & temper	Oil at 130° F.	715° F.	C-40.5-41
	Austemper	Salt at 630 for 45 min.	None	39.5-40.5
	Martemper	Salt at 630 for 1 min.	500 & 715	39.5-43
	Martemper	Salt at 400 for 1 min.	715	39.8-41
6150	Quench & temper	Oil at 130° F.	690° F	C-51
	Austemper	Salt at 585 for 2 hr.	None	51-51.5
	Martemper	Salt at 585 for 1 min.	500 & 690	52.5-53
	Martemper	Salt at 400 for 1 min.	690	51
4063	Quench & temper	Oil at 130° F.	595° F.	C-53-53.5
	Austemper	Salt at 530 for 90 min.	None	53.5-54
	Martemper	Salt at 530 for 1 min.	500 & 595	53.5-54
	Martemper	Salt at 400 for 1 min.	595	53.5-54

Summary

The data obtained in this investigation indicate that the relationship between hardness and tensile strength of low-alloy steel is about the same whether the specimen is austempered or quenched and tempered. For the same hardness and tensile strength, austempering results in somewhat lower yield strength, slightly higher ductility as measured by reduction of area in the tensile test, slightly higher endurance limit, and slightly greater notch toughness except at low test temperatures. All of these differences, except in yield strength, are small, sometimes less than the normal scatter from causes other than heat treatment method.

In no instance was the ductility, notch toughness, or endurance limit of these austempered steels found to be inferior to those produced by quenching and tempering in the conventional manner. It should be pointed out, however, that poorer properties may result from transformation at too high a temperature, because of inadequate hardenability or use of a high austempering temperature, as shown by other investigators.[5]

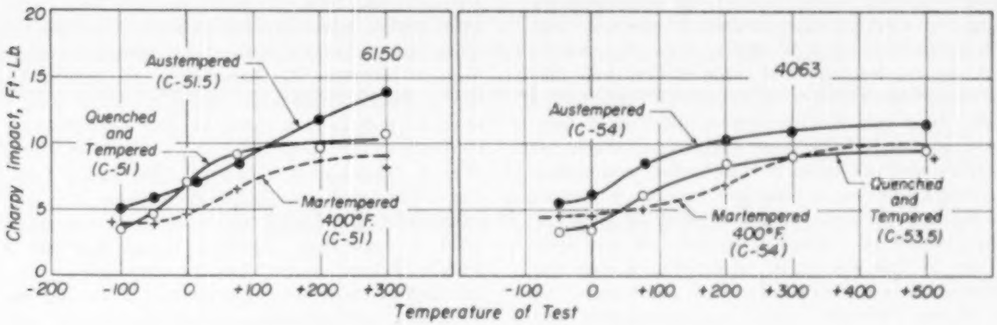


Fig. 4 — At Higher Hardness Levels (C-50 to C-54) Method of Heat Treatment Makes Little Difference in Charpy Values at and Below 0° F. for 6150 and 4063

Critical Point

Letter From Canada

St. John, N. B.

A CITIZEN OF THE UNITED STATES should take a long and leisurely trip, transcontinental in fact, to appreciate the friendly spirit of the Canadians, to find that we on both sides of the line are essentially "Americans" — members of a large political unit — and that they are more aware of this than we are, and to glimpse the potentialities of their vast area. Especially to the West he would get an inkling of the endless opportunities seen by the pioneers in the United States, 100 years ago, as they pushed over the prairies and through the Rockies. In eastern Canada the St. Lawrence dominates the country's life and economy, as well as the scenery along the main highways. An enormous river, even at its source in the lovely Thousand Islands, it receives the tribute of dozens of others, steadily growing into an arm of the ocean itself, and the Labrador shore fades below the horizon.

This river, the main highway of commerce, appears to divide Quebec into two sections. To the north, aside from a narrow strip along the shore, is rolling, timbered, lake country, inhabited by fish, deer, mosquitoes and crows. To the south, the country has long been cleared and cultivated — only in Gaspé peninsula in the far northeast has the contest between man and weather reached a stable truce. Here the *habitants* are busily trucking off their forests to the paper mills; evidently a comic supplement is more valuable than a living spruce, one among billions.

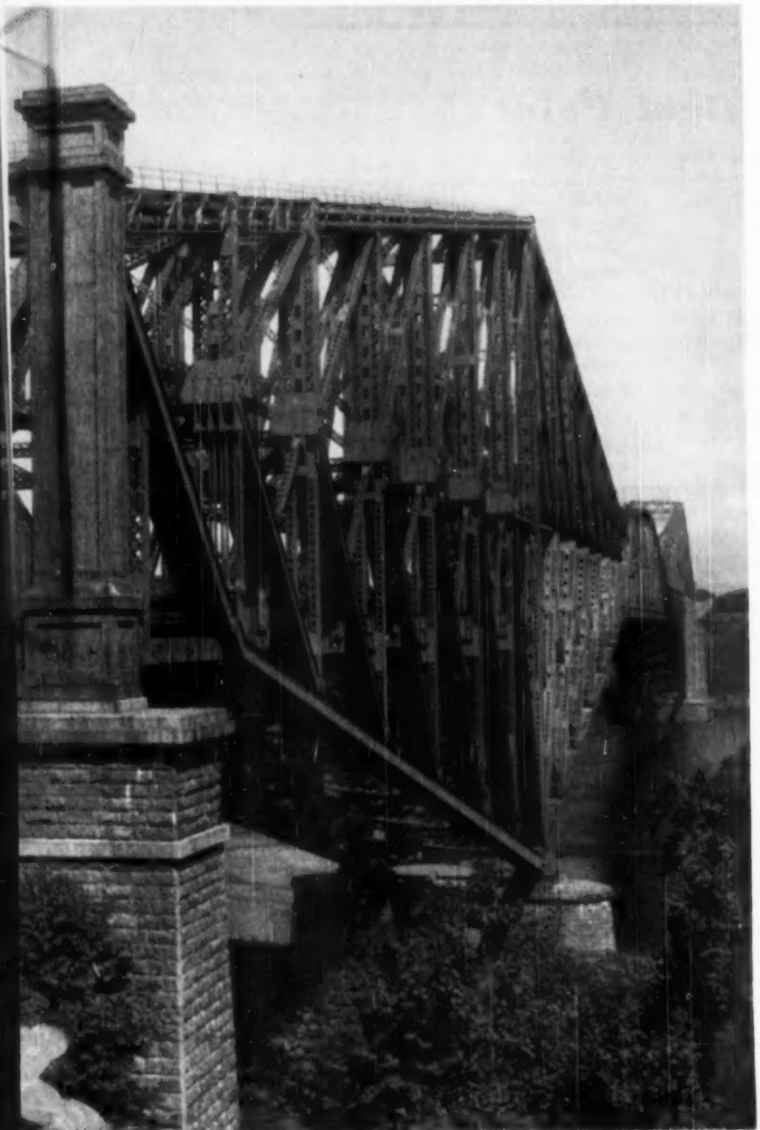
In this Gaspé country the principal industries seem to be lumbering, church (vying for first position), fishing, farming, taxi driving. Food is uniformly excellent and remarkably inexpensive. Roads are uniformly rough and unmarked (especially at intersections), twisting and steep, but mercifully and entirely clear of billboards and canteens — "hot dog stands" in Americanese.

To the south and east is Nova Scotia and Cape Breton Island, where the only coking coal in Canada's eastern area is mined. But coal mining seems to do something to man and countryside; the visitor gladly leaves the drab area near Sydney for the beautiful shores of the great Bras d'Or, an inland lake big enough to harbor all the world's fleets since Noah built his ark. Nova Scotia resembles eastern Pennsylvania in many respects, at least along the main highways leading to Halifax. Halifax itself is as interesting a city as our Williamsburg in Virginia. And as for St. John, your correspondent cannot say, for this morning it has retired behind a Bay of Fundy fog.

And now to summarize technical notes taken on this busman's holiday, touring Quebec and the Maritime Provinces: Leaving that most excellent Chateau Laurier and visiting the Canadian Bureau of Mines, H. J. Nichols, welding metallurgist, was

found worrying about methods and equipment for repairing mechanized ordnance in subzero, subarctic weather, and J. W. Meier, research metallurgist, rolling hot ingots of nodular cast iron into slabs and (hopefully) into concrete reinforcing rods. Next day, Neville Spence, director of technical service for Dominion Magnesium, drove me 60 miles west of Ottawa to Haley where magnesium is made by Professor Pidgeon's process (reduction of calcined dolomite by ferrosilicon in vacuum) and calcium is reduced from lime in the same retorts by fine aluminum. Returning, a stop was made at the associated foundry, Light Alloys, Ltd. in nearby Renfrew, where one interesting and characteristic item of production is long canoe skids which, when attached bow to stern, turn the canoe into a sled for the long portages. . . . . Thence deep into the Laurentians to Bark Lake, where Curry Carmichael, ● past-trustee, has a summer cottage. In front of the wood fire we couldn't avoid shop talk; he recalled a World War I campaign at Anniston (Alabama); "synthetic pig iron" was being made from scrap in small Heroult furnaces, and melt-down was shortened by some coke, shoveled in and fed with a trickle of tank oxygen (process patented!). . . . . Carmichael turned me over to Bert Williams, the hospitable and soft-spoken superintendent of metallurgical operations of Shawinigan Chemicals, Ltd. All of the calcium carbide made in the furnace plant at Shawinigan Falls, largest in the world, is turned into acetone and plastics by reactions undiscovered or of mere academic interest 40 years ago when farmers lit their homes with acetylene. . . . . North from Quebec, over 120 miles of fine new high-speed road through Laurentide National Forest, to the village of Arvida. Here Aluminum Co. of Canada operates what is perhaps the most northerly metallurgical plant on this continent, and certainly the world's largest producer of aluminum ingot, thanks to wartime expansion. "Mac" Young from the general offices in Montreal, with Messrs. Horwood, MacQuarrie, Donnelly and Johnson conducted a tour from tide-water Port Alfred on the noble Saguenay River to Shipshaw power plant (rivaling Grand Coulee's), through bauxite refinery, pot rooms, melting department, and completely automatic rod mill — ending with a merry dinner party at a cozy tavern on the edge of the forest. . . . . On to Sydney, Cape Breton Island, and the most easterly metallurgical plant of North America. Dominion Steel and Coal Corp. here makes 2000 tons of steel ingot every day from ore mined in Newfoundland and coal taken from seams far out under the ocean. Nearly half the steel goes into rails (I. C. Mackie, who discovered the cure for internal transverse fissures, is director of metallurgical research); nearly all the rest goes into wire, nails and fencing. . . . . Of these brief notes, more in detail later. ERNEST E. THUM

Quebec Cantilever Bridge Is Big by Any Yardstick



A review of Russian metallurgical journals, their origin, history and untimely disappearance; with notes on the shifting tactics in Soviet reporting of production figures.

The Iron Curtain in Metallurgical Literature

THE EDITORIAL COMMENT and abstracts of Russian metallurgical articles published in the June issue of *Metal Progress* were of particular interest to me, because I have been concerned with Russian technical publications for several years.* The editors remark that the Russians may consider certain technical journals unsuitable for export. Quite correct! In fact, this iron curtain started to close perceptibly about ten years ago. It may be of interest to record something further regarding the ebb and flow of Soviet metallurgical journals since their comparatively recent inception.

It all started with the first five-year plan (1929). Applied to the Russian steel industry, this plan envisaged the building of such new works as Magnitogorsk (where everything is "the biggest in the world"). A frightening lack of Russian technical brains for the tasks ahead became apparent, and foreign engineers were imported. Together with this stream of experts came foreign technical journals. Understandably, the Soviets wanted journals of their own, and in the years between 1929 and 1934, a truly astounding metallurgical literature sprang up.

There was, above all, the monthly organ of the Five-Year Plan Committee for the Steel Industry, called "Soviet Metallurgy" *(Sovetskaya Metallurgiya)*. This journal appealed chiefly to iron and steel engineers and also carried the monthly production figures of the "capitalistic" countries, but significantly and quite in keeping with the iron-curtain mentality, not those for Russia. I have No. 1 and 2 of 1938, so the journal must have lasted at least ten years.

An even older technical journal was "Metallurgist" *(Metallurg)*, a handsomely made-up monthly, started in 1926 and devoted to both ferrous and nonferrous metallurgy. The circulation rose to 4000 before this journal disappeared abruptly in 1940. During the 15 years of its existence, "Metallurgist" published more than 400 articles on metallography, 150 on rolling, more than 100 on the production of steel, almost 100 on the production of pig iron, and 130 on the production and the processing of nonferrous alloys. The level of the articles, theoretical as well as practical, was remarkably high because the section editors were the best to be found in all Russia.

In 1929, still another monthly was founded for the steel industry, entitled "Achievements of Metallurgy at Home and Abroad" *(Domez)*. The content was divided about equally between original contributions of a practical nature (most of them with a distinctly local slant) and detailed abstracts, often illustrated, of the foreign literature. The life

*EDITOR'S NOTE: The author is too modest. He started translating foreign metallurgical papers on a free-lance basis in 1926, after his arrival in this country from Bavaria. Following a period with the short-lived Republic (Steel) Research Corp. in the early 1930's, he established his own organization, and has been described by one of America's most eminent metallurgists as having "uncanny ability in technical translating". Mr. Brutcher's translations are especially well known in metallurgical laboratories and research institutions.

By Henry Brutcher
Altadena, Calif.

of this journal was short; it ended with No. 10 of Vol. 7.

In the same year, 1929, the old "Journal of the Russian Metallurgical Society" *(Zhurnal Russkogo Metallurgicheskogo Obshchestva)* expired after a more-or-less continuous existence of almost 20 years. Among its contributors we find the names most illustrious in Russian metallurgy and metallography: D. K. Chernov, one of the early students of metals who achieved international recognition; Col. N. Belaiev, long since living in France; A. A. Bochvar, probably best known from his textbook on metallography; A. A. Baikov, a prolific writer and excellent teacher (the Academicians N. T. Gudtsov and N. V. Svechnikov, and Professors N. A. Minkevich, B. V. Stark, and M. P. Slavinskii were among his pupils). Other pre-Soviet journals possibly of interest to metallurgists were the "Bulletin of the St. Petersburg Polytechnic Institute" *(Izvestiya SPB Politekhnicheskogo Institute)*, "Ural Technics" *(Uralskii Tekhnik)*, and the "Journal of the Russian Physical-Chemical Society" *(Zhurnal Russkogo Fiz.-Khim. Obshchestva)*. In the 1907 volume of the latter, we find a paper on the crystallization and structure of steel by A. A. Baikov, the same Baikov who in 1944 took part in a lively discussion on the use of oxygen in blast furnace operation.

In 1930, a fourth monthly devoted entirely to ferrous metallurgy appeared under the name "Theory and Practice of Metallurgy" *(Teoriya i Praktika Metallurgii)*. Despite the duality in name, most of the papers were practical. Like "Metallurgist", this good journal disappeared without warning or a farewell, in December 1940. During the second half of its life, it paid increased attention to problems of plant construction; the rest of the articles dealt with iron and steel production, rolling, and quality control. Special attention was given to seamless tube production as, at that time, tube mills were first started in Russia.

The year 1930 was marked also by the beginning of the most important Russian journal on welding. It is still being published, and received here, under the original title "Autogenous Welding" *(Avtogennoe Delo)*, but the name must not be taken literally, as all of the welding processes receive attention. In the same year, the first issue of the Russian "Foundry" *(Liteinoe Delo)* appeared. This was an interesting experiment — each of the articles could be easily detached and filed separately according to a convenient system, and each page was fully indexed at the top. Even the translations from the foreign literature were treated in this way. It expired with No. 6 in 1941, but may since have been revived.

In 1931, the important event in Russian metallurgical literature was the appearance of "Steel" *(Stal)* in the South of Russia (Kharkov), under the editorship of the eminently able I. P. Bardin,

All of These Russian Metallurgical Journals Are Now Defunct, Except Possibly "Metal Industry Herald"

Metallurgical Journals Currently Published in the Soviet Union. Only "Autogenous Welding", "Machine Tools and Instruments" and "Machine Building Herald" are still exportable. When will they become "oversubscribed"?

member of the Academy. This journal, the fifth of the series devoted to ferrous metallurgy, contained an enormous amount of information. Each issue carried from two to four articles on each of the following subjects — blast furnace, steel production, rolling, metallography, and heat treatment. There were also papers on power economy and several detailed abstracts of important foreign papers. Without any advance warning, this fine journal ceased publication in December 1940, but in January 1941, a new one of the same name made its appearance, this time from Moscow and under a relatively unknown editor. Its coverage was no less extensive than that of the old "Steel"; however, three other worthy journals in the ferrous field had been sacrificed.

Let us go back to 1932. In that year, the journal "Rare Metals" *(Redkie Metally)* made its appearance; its columns were devoted to metals such as beryllium, zirconium, columbium, tantalum, tungsten and uranium, and a number of other metals which in this country would not be considered rare (for example, molybdenum, tin, mercury and lithium). Refractory carbides also received much attention in "Rare Metals". It disappeared with the first issue of 1938. Another journal, "Light Metals" *(Legkie Metally)*, covering aluminum and magnesium also expired in 1938.

A third nonferrous journal, called "Colored Metals" *(Tvsetnye Metally)* has been enjoying a longer life. When, in 1941, it merged with "Gold Industry" *(Zolotaya Promyshlennost)*, it acquired the name "Colored Metallurgy" *(Tsvetnaya Metallurgiya)*; however, it has since resumed its old name and appears six times a year. The Russian journal with French title, *Annales de l'Institute de Platine et des Autres Métaux Précieux*, which in 1936 changed its name to "*Annales du Secteur de Platine*, etc.", recalls the fact that Russia has always had a most important share in the world's production of platinum and that the first bona fide platinum coins were struck in that country (but not for long — the dollar value of a 3-ruble piece, $2.30 when struck, would now be about $200.00).

Several Russian journals have carried articles in non-Russian languages at various times, and the foreign language translations of the tables of contents have always been an indication as to which way the political wind was blowing. Just before the last war, they were in English and French; before that, often in German; during the Soviet friendship with Hitler, they were consistently in German; for a short while after the war, in English; when the French entered an alliance with the Soviets in about 1946, also in French; and

(Continued on p. 368)

An Eminent Living Metallurgist

Frederick F. Frick

Our Biographical Dictionary

At the celebration of the 75th birthday of the Colorado School of Mines, a number of its eminent graduates were awarded citations for distinguished achievement. Among these was Frederick F. Frick of Anaconda, Mont., Metallurgical Engineer, Class of 1908. These were the words:

> As research engineer for Anaconda Copper Mining Co. since 1915, in charge of research, testing, sampling, and chemical work, Frederick F. Frick has had a major part in the following developments: Roasting and leaching of copper mill tailings, the application of coal dust firing to reverberatory furnaces, the flotation of Butte copper ores; the electrolytic zinc process used by Anaconda; processes for treatment of Chilean copper ore, Montana chromium ores, and mine waters and low-grade copper ores from Butte; the production of metallic arsenic and sponge iron; the production of phosphate fertilizer and the recovery of a vanadium byproduct; the flotation of manganese ore, nodulizing the concentrate, and the production of ferromanganese.

These formal words mean that Fred Frick has all his lifetime worked in a quiet, efficient way, solving those metallurgical problems that meant actual survival for a large segment of our American copper industry. His success in treating low-grade, complex, fractious copper ores inevitably gave him a leading role in the search for ways and means of recovering byproducts, and commercialization of no less difficult processes for zinc, bismuth, manganese and vanadium.

Frederick F. Frick was born in Chicago, May 4, 1882, and was raised in Peru, Ind., where his father operated a small iron foundry. He graduated from high school in Peru and attended the local college for one year, and then decided to stay out of school until he found what he wanted to do.

He became a laboratory assistant in a small steel plant, making routine chemical analyses, and so became interested in metallurgy. He went west and enrolled in the Colorado School of Mines, from which he was graduated in metallurgy in the spring of 1908. When his senior class made the customary tour of mines and smelters, Frick remained in Montana, and went to work for the Anaconda Copper Mining Co. The lure was too strong to resist. The smelter there was a model plant (for those days) of modern layout and construction; the management was a model group (for any time) of friendly engineers, technologists and operators.

His first job was laborer in the converter plant. This was before the day of basic linings and large shells, and the clay mill where the silica lining for the small converters was mixed was a dusty pandemonium. Next he was a fireman in the reverberatory department. The furnaces were coal fired at that time, with exposed inclined grates 7 x 16 ft. in area. The slicing bars for breaking up the clinker were long and heavy; according to Fred, they weighed as much as he did toward the end of the shift!

Within six months, however, the desired opportunity came and he joined the technical staff. There he formed a close and enduring association with Frederick Laist, then chief chemist, later to become Anaconda's vice-president in charge of metallurgy.

Five years later (1913) Frick was transferred to the testing department, then headed by C. D. Demond. (Mr. Demond is remembered as a sparse-bearded patriarch who did not hesitate to admonish his young assistants to hew to the straight and narrow path!) This test department, at the time, was studying the smoke problem. Butte ores were sulphides and contained a trace of arsenic; the farmers in the near-by Deer Lodge Valley constantly complained that the sulphur smoke was ruining their crops. An exhaustive investigation was under way to determine accurately the gas volumes, velocities, and emanations from the main flue and stack. This work resulted in a really huge Cottrell precipitator for cleaning the smoke. Many present-day testing methods, both physical and mechanical, were pioneered on this job.

In the years following 1912 the pressing problem was to devise methods to make better recoveries from the leaner and leaner copper ores reaching the concentrator. The record of these years is filled with Frick's studies of various concentrating circuits and machines, both gravity concentrators and flotation cells — many of them promising machines at the time, but whose names have been forgotten by most copper metallurgists.

The treatment of ore slimes was a critical problem. Prior to 1914 the slimes had been impounded, the ponds dredged, the solids briquetted and added to blast furnace feed. (How much was smelted and how much was blown out into the flue was a topic for constant argument.) But blast furnaces were on the way out — there was no good coarse ore left for them to smelt — and in 1914 the first tests on fine grinding and flotation circuits were started at Anaconda, work which led to the rebuilding of the Anaconda concentrator three times during Frick's tenure as Research Engineer.

Also, in 1914, the first experimental work was begun on the electrolysis of zinc sulphate solutions as a method for producing metallic zinc. (Zinc was a neglected stepchild in the Butte mines.) Although Frick has many patents and many operating processes to his credit, his connection with electrolytic zinc is probably his greatest contribution to the

metallurgy of our times. Without detracting from the part played by the others in the original experimental group, it is proper to note that Fred Frick was in charge of the laboratory work and the subsequent pilot plants before the process was expanded to commercial production. Some of the ideas were his, and some came, of course, from the others, but his was a major influence in the ultimate success. The large plant was built in Great Falls, and most of those connected with its operation moved there too. Frick, however, chose to remain in Anaconda as Research Engineer (1915), the position which he has held ever since.

Copper ores had been concentrated in Anaconda since the heyday of Marcus Daly, and millions of tons of tailings, more or less oxidized, were spread over the flats. A certain amount of copper could be recovered merely by collecting the water that seeped through these heaps and running it over scrap iron. Study of this leaching and iron precipitation cycle led to a 2000-ton leaching plant, and a chamber sulphuric acid plant (using sulphur from smelter smoke) was constructed to supply auxiliary leaching acid. Searching for further outlets for sulphuric acid led to an experimental superphosphate plant in 1916, and a constant expansion and improvement of fertilizer manufacture — all done under Frick's supervision.

An associated idea to which Fred applied his talent required a long time to develop. It was the recovery of vanadium from the phosphoric acid solutions in the treatment of Idaho phosphate rock. Work on this problem started in 1925, but it was not until 1940 that the vanadium recovery plant was built — a fine example of the recovery of a trace metal in extremely high purity.

The early 1920's saw Frick developing a method for treating the mixed ore at Potrerillos, Chile, culminating in the building of the Andes Copper Mining Co.'s plant. Counter-current acid leaching, separation of ferric iron by lime rock purification, and electrolytic deposition of the copper was finally adopted for the oxide ores. He went to South America for the Andes Co. in 1928, and a year later moved to the Chile Copper Co.'s plant at Chuquicamata. Here his work led to the use of soluble lead-arsenic anodes which replaced the old brittle "Chilex alloy". He also developed a method for using sulphur dioxide to stabilize the catalytic reaction between molybdenum, ferric iron, and nitric acid which had for so long plagued the Chuquicamata electrolytic tank room.

Steel metallurgists know how essential manganese is to their industry. Few realize that practically all of the ore of metallurgical grade produced in the United States comes from Montana. Although this is only about one eighth of our actual requirements, Americans would not have even that nest egg without some lengthy work on another stepchild of the fabulous Butte hill: Ferromanganese had been produced in Great Falls direct from the rhodochrosite ores of the Butte district during World War I, but was not an unqualified success and could only operate on 35% manganese ore, of which there was a limited supply. Flotation of low-grade manganese ores was first tried in the Anaconda Research Department in 1926. In 1930 a 500-ton-per-day experimental test was made; costs were unattractive. Testing continued on a laboratory scale until 1938 when a satisfactory reagent combination was developed and taken through the pilot-plant stage. This work resulted in a complete manganese flotation unit which treats 12 to 18% manganese ore, producing a concentrate which is further beneficiated to 60% grade by kiln nodulation. This plant ran through World War II and is operating today, having been recently augmented by five electric furnaces for the manufacture of 80% ferromanganese from the kiln nodules.

This résumé covers but a small part of Frederick Frick's work over the years, but does include the high lights and gives some idea of his diversified interests and his successful busy career.

In 1913 Ella Strand became Mrs. Frick. They have a married daughter Mary, who is now Mrs. Clyde Longstreet of Long Beach, Calif. The Fricks live unostentatiously in Anaconda, Mont.

Frick's approach to a problem is meticulous and painstaking. As a rule, he does not believe in shortcuts or taking chances, and when the job is finished one can be assured that the answers are reliable.

He always has had little regard for sloppy work and does not appreciate excessive theory without visual proof to back it up. He is always going out into the laboratory himself to make a few beaker tests so that he can actually see and feel the reactions and products. He is a staunch believer that one can learn a great deal from a few hours spent in applying standard qualitative analytical tests before seriously attacking a problem in metallurgy or chemistry. Many times he has proven his point.

Great though his direct achievements may be, indirectly they are even greater. The Research Department at Anaconda under Frick's supervision has afforded a post-graduate course for scores of junior metallurgists fresh from college. In four decades a large number of men have worked with him, and are the better for having done so. Today they are scattered throughout the nonferrous industry in responsible positions, ready to solve the difficult problems of tomorrow.

C. P. Donohoe

A thin water emulsion of colloidal graphite is a superior coolant and lubricant for hot-work dies, and the spray nozzles, attached to frame of forging machine or recessed in the dies, can easily be automatically controlled.

Forging Die Lubrication

THERE is probably no phase of lubrication which has been more neglected or less scientifically carried out than the lubrication of forging dies for steel and nonferrous metals. Tradition, the fancy of the particular operator, and habit have usually been the determining factors in the choice of lubricant, if any, and its method of application.

When the conditions under which these dies operate are considered, adequate lubrication appears mandatory. The hot metal is forced over the die surface at high pressures, and it is a tribute to the inherent toughness of good die steels that earlier failure does not occur with such lubrication as may have been provided.

Sometimes no lubricant of any sort is used. In many other cases, salt water solutions, graphite and oil, or oil alone are swabbed onto the die to relieve any tendency for the forging to stick. In the course of time, the swab and lubricant become contaminated with scale and other abrasive dirt from the vicinity. It is difficult to say whether rapid die wear is caused more by poor choice of lubricants or by the suspended abrasive particles introduced by the swab.

Reviewing the factors and conditions which are involved, a suitable lubricant must, first of all, be stable under the high temperatures and pressures involved. Conventional petroleum oils and greases break down to form abrasive carbon, varnish-like deposits, and smoke at temperatures above 300 to 400° F., which is far below the existing metal-working temperatures. Any lubricant which volatilizes under the heat of the forging operation may hasten die failure by penetrating the minute fatigue fissures on the surface under enough heat and pressure to expand these cracks until severe "die checking" results. In addition, oils are ineffective to keep die temperature down owing to their low specific heat. If the die surface can be kept relatively cool it will naturally improve the durability of the die. This cooling effect probably accounts for the limited use of salt water and its slightly beneficial effect in some cases; salt water is not, however, a lubricant and falls far short of being acceptable for this reason.

Graphite, being a material having excellent lubricating properties and being unaffected by temperatures considerably higher than those existing in the die, is found to do an excellent job if properly applied. Ordinarily powdered graphite cannot be effectively used because there is no way of applying it except by mixing with oil, wherein it settles rapidly; in addition we have the natural objections to oil as mentioned above.

On the other hand, colloidal graphite (in the commercial form — a concentrated dispersion in water) can be greatly diluted with water without settling and has the unique property of plating on the hot die to form a surprisingly durable "graphoid" surface which provides lubrication in the form of an almost invisible film. Due to its extremely small particle size the carbon is physi-

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cally combined with the surface metal (adsorbed). The water with which it is diluted is principally a carrier which evaporates immediately on contact with the die surface, leaving no deposits or smoke.

In fact, tests recorded by C. R. Hoagland in *American Machinist* for Dec. 2, 1948, and by Herbert Chase in *Iron Age* for May 27, 1948, have shown that when dies were coated with colloidal graphite before being put in service (actual forging being done dry), die life was almost doubled. While lubrication during the critical breaking-in period of new or reworked dies is important, it is reasonable to assume that the use of colloidal graphite during the forging run will materially improve results. This has been proven in practice.

One obstacle has been the lack of properly designed spraying equipment to replace the traditional swab. Few spray guns are made of stainless steels or nonrusting materials, and many of them are made to spray in a forward direction only. They are therefore inconvenient to use where the surfaces are in a horizontal position and space is restricted. To use them around a hammer or press the operator must assume an awkward position and expose himself to the possibility of serious injury should the hammer or press be inadvertently operated. Some types require a liquid supply under pressure; this involves costly tanks, difficult to refill. Others, with container attached, are heavy and require frequent filling.

To overcome these objections, simple, inexpensive spray nozzles have been designed which

Concentrated Colloidal Graphite Is Applied to Cavity and Top Surface of Die at 200° F. This application of graphite has nearly doubled die life. Photo courtesy International Harvester Co. (Fort Wayne Works)

develop enough suction to draw liquid up from an open container on the floor, and spray at a 90° angle up and down at the same time, if desired. They can be adapted to a portable hand gun or to a fixed mounting for intermittent operation by a foot valve or by automatic control. Lower die temperatures are easily maintained without wasting valuable graphite by increasing its dilution, applying it in the form of a wet spray for the proper time to secure the desired effect.

For fixed mounting, these nozzles can be attached to any convenient point on the machine, or the dies can be provided with recessed slots in their shoulders for mounting the nozzles in such a way that the bottom nozzle sprays the top die and vice versa. Some of the new dies used in the Louisville (Ky.) plant of International Harvester Co. are being designed in this manner. In addition, air valves are to be actuated in such a way that the spray is turned on during a certain period, thus relieving the operator and insuring proper application of lubricant at desired frequency.

It has been found that a dilution ratio of one part concentrated colloidal graphite in water to 100 parts water by weight is about right — that is, 4 lb. of concentrate to 50 gal. of water. For longer or wetter sprays (for cooling), still further dilutions may be employed. Although a mixture of 1 lb. of concentrated colloidal graphite in water to 2 gal. of water (1:16.5 by weight) is generally used to pretreat dies (brushing the emulsion on preheated dies), a repeated spray of much more highly diluted material should yield better results. A thick coating is never advantageous.

For example, a test was recently made on a die used to forge a long flat part from round stock by spraying a dilution of one part concentrated colloidal graphite in water to 240 parts of water on one half of the upper die only. As the die is quite long, the spray was arranged to impinge continuously over the half where the wear had always been severe. The difference in rate of wear was very apparent; the sprayed portion wore at one third the former rate. As this is a mass production item (a truck body brace) and as there had been several years of experience in running it, sufficient data had been accumulated to make the comparisons quite conclusive.

A few precautions insure optimum results:

1. The original die surface should be free from oily deposits. A good wiping with a volatile naphtha is recommended.

2. The die should be preheated to about 250° F. or more.

3. The water should be reasonably pure. Most city waters, oil-free condensate, or distilled water are entirely satisfactory as diluents.

4. Mixing should be complete; no lumps or undispersed agglomerates.

5. Use rust resisting containers and pipe lines. Rubber hose and copper tubing are convenient for lines and an ordinary galvanized garbage can serves well as a cheap container, easily filled and with a lid to keep out dirt. A check valve in the pipe line near its entrance to the can assures constant liquid supply to the guns.

6. Unlike oil, the rapid evaporation of the water prevents the coating from creeping or spreading to unsprayed parts. This is particularly important in deep impressions where draft may be inadequate. The spray, therefore, should cover all surfaces of the die.

There are other advantages of this system that might not be apparent:

1. Besides reducing wear on expensive dies there is an actual saving of steel stock by keeping the forged parts down to their proper size. In a large plant this may amount to $2000 on a single forging in a year's time.

2. A clean die results in much better finish on the forgings.

3. Faster production results from proper arrangement of spraying equipment, as it relieves the operator of the swabbing operation. Time out to cool a hot die can be avoided by the cooling effect of the spray.

4. Elimination of smoke and fumes improves working conditions.

5. There is less downtime for die removal and reworking.

Colloidal graphite is not a cure-all for all of the difficulties that may be encountered in a forge shop. If dies are worn or improperly designed, it may not prevent the work from sticking in the dies. There will be no pressure generated under the forging to "blow it out", as is sometimes possible with oily lubricants. While sometimes effective in expelling the forging, oil is very detrimental to die life, as explained on the first page of this article.

The cost of colloidal graphite represents only a very small fraction of the total cost of a completely forged article. For example, at a dilution ratio of 1 to 100 the cost of the mixture is about 30¢ per gal. Greater dilutions are proportionately cheaper. Translated into cost per part of a representative forging, the 1 to 100 dilution would represent about 0.1¢ per piece for a connecting rod for a moderate sized tractor engine.

Colloidal Graphite in Water Is Sprayed on Connecting Rod Dies at International Harvester's Louisville Plant

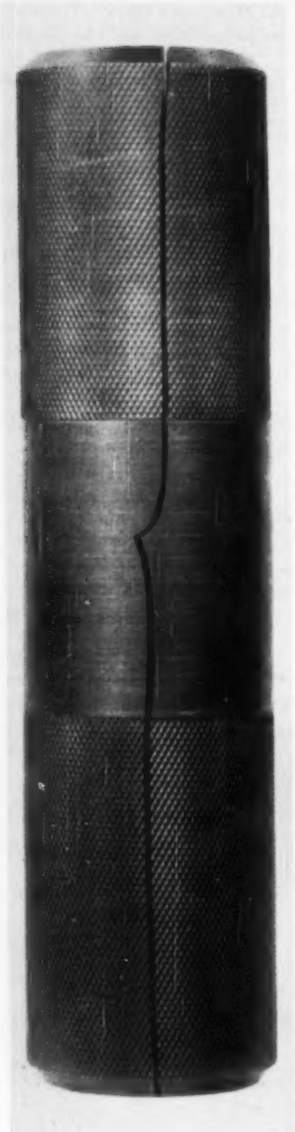

Fig. 11 — Gage, 1⅜-In. Diameter x 7¼ In., Made of Manganese Oil Hardening Steel. Cracked because of failure to temper immediately after the quench, even though the tool has no abrupt changes of section. (Figure numbers are continuous with those in the first part of this article)

In the investigation of several thousand tool failures, the author and his metallurgical associates have found that about 80% of the failures were caused by improper heat treatment. Examples of tools that cracked during or shortly after incorrect heat treatment are illustrated, and recommendations are given for avoiding such cracking.

Causes of Tool Failures

II — Improper Heat Treatment

As was illustrated in the first part of this article, in last month's *Metal Progress*, the causes of tool failure are diverse and sometimes difficult to classify. A certain fraction of such failures can be traced to faults in design or mechanical processing; some are a result of unusually high service loads; a few are due to defects in the steel. But the largest proportion of tool failures — about 80% — are caused by improper heat treatment.

The failure of tools to harden in heat treatment is a subject needing only brief mention, as most heat treaters know how to correct this type of trouble. Unsatisfactory hardening of tools is most likely to be caused by: *(a)* failure to heat to a high enough temperature, *(b)* failure to quench at a fast enough rate, *(c)* decarburization of the surface metal, leading to soft skin, or *(d)* retention of too much austenite as a result of heating to an excessively high temperature.

Failures of tools by cracking during hardening, or shortly after hardening, are the most difficult to analyze and to explain with any degree of satisfaction to the owner of the cracked tools.

The basic heat treatment operations necessary to harden any of the standard types of toolsteel involve simply heating the steel to a sufficiently high temperature and then cooling at a rate fast enough to develop the

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desired hardness; quenching is practically always followed by tempering, in order to reduce stresses induced by quenching, while sacrificing a minimum of hardness.

The preceding sentence is perhaps an oversimplification of the methods of heat treating tools. At the other extreme are the specific instructions given in the manuals of most toolsteel manufacturers and the recommended practices published in the toolsteel section of the A.S.M. Metals Handbook. By carefully following such instructions based on collective experience, those responsible for the heat treatment of toolsteel can go far toward avoiding cracked tools. The following notes on the various operations may help to clarify some of the detailed instructions which are already in wide circulation.

Stress Relief — Where the most accurate tool work is being done, it is often desirable to stress relieve the tool *before* hardening it. This is particularly appropriate for tools that have been highly stressed by heavy machine cuts, cold hubbing, forming, or other shaping processes; if unrelieved, the residual stresses from such operations may add to the thermal stress produced in heating and cause the tool to crack before it has reached its quenching temperature. However, it is important to realize that after stress relieving, the tools must be remeasured and any dimensions that have been changed as a result of the stress relief operation must be corrected. If this is not done, excessive distortion will probably be found in the hardened tool. (This preliminary stress relief has no effect whatever on distortion that may occur later as a result of martensite formation during hardening.)

Preheating — Practically every publication on toolsteel recommends that tools be carefully preheated immediately before they are heated to the quenching temperature. This preheating is usually just insurance; it may not be beneficial but it cannot be detrimental. In the majority of small tools, where no appreciable amount of cold work (such as would occur from stamping, punching, shearing, cold hubbing, or hogging in machining) has been done, preheating is not actually necessary if the quenching temperature is below 1600° F., and no disastrous results would be expected from the elimination of the preheat. However, if a tool has been appreciably cold worked, if it is not in a fully annealed condition, if it has large sections or heavy and light sections adjacent it should be preheated to avoid excessive temperature gradients that could cause warping or cracking during heating.

When the quenching temperature is 1600° F. or higher it is usually advantageous to preheat tools, regardless of their shape or previous processing history. This is because a preheat makes it easier to heat a tool uniformly to the quenching temperature. Also, when the quenching temperature is high, it is necessary to use the shortest possible time at high temperature, to minimize scaling and decarburization. Preheating facilitates this.

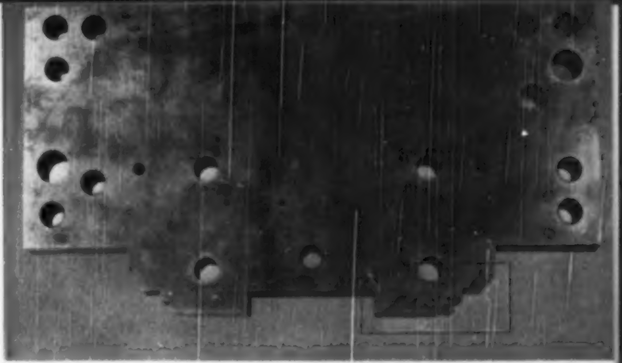
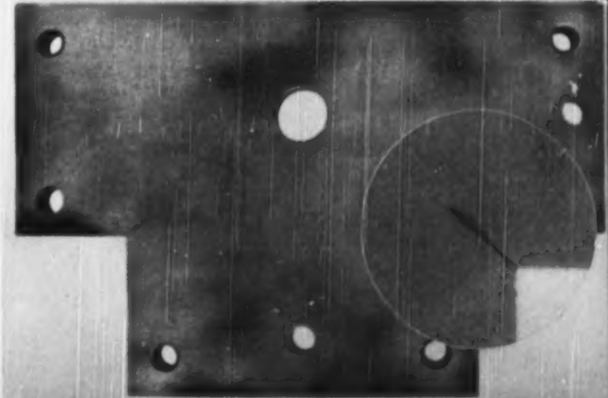


Fig. 12 — Die, 9⅛ x 4½ x 1⅛ In., Made of Manganese Oil Hardening Steel. Cracked in sharp corners because of failure to temper immediately after the quench. View at right shows the cracked portion at approximately full size

Quenching — All liquid quenched tools should be quenched to between 150 and 200° F. Air hardening steels should be cooled to 150° F. These temperatures can be estimated by a fearless operator who is willing to pick up the tool barehanded (the "average heat treater" can endure 150° F. momentarily, but not 160° F.) or by a more cautious — and less fastidious — individual who will spit on the tool first to see if it is hot enough to sizzle (212° F. or higher). The modern heat treater is more likely to use "Tempilstiks" or a contact pyrometer for judging the temperature of freshly quenched tools.

Tempering — As-quenched tools often have residual stresses close to the ultimate strength of the steel. The function of tempering is to decrease such stresses enough so that the tool can perform its intended service without cracking or failure.

Fig. 13 — Die, 9 x 6 x 1 In., Made of Manganese Oil Hardening Steel. Cracked through both sharp corners because of quenching too cold and failure to temper immediately after the quench



Since a given amount of stress relief requires more time the lower the temperature and since tools are usually tempered at lower temperatures than ordinary alloy steel parts, the duration of tempering is usually greater for tools than for other quenched steel objects. In the higher ranges of tempering temperature (for example, 1000 to 1200° F.), as often used on shock resisting tools, it is less important to temper for an extended period because stress relief occurs more rapidly.

Double Tempering — Some types of toolsteel such as high speed or hot work steels require double tempering to put them in the best condition for service. This is because these steels retain more austenite than the steels of lower alloy content. The first tempering relieves stresses in the martensite formed in the quench and conditions the retained austenite so that it transforms to martensite during cooling from the tempering temperature. A second tempering operation is necessary to relieve stresses due to the newly formed martensite. The omission of a second temper on hot work steels may lead to early failure by heat checking; on high speed and high-carbon high-chromium steels, such omission may result in abnormal sensitivity to grinding checks.

Martempering — Some heat treaters prefer to harden the oil hardening grades of toolsteel by martempering. The advantage of martempering is that hardening occurs more uniformly throughout the section during air cooling from the molten salt bath in which the tool is quenched. Thus, the warpage resulting from a drastic liquid quench is avoided. However, martempering has no effect whatever on the expansion that occurs when martensite is formed.

There are also instances on record where improper martempering has aggravated cracking troubles rather than eliminated them.* It is recommended that martempering be used only for hardening under close metallurgical control or when the repetitive nature of the work allows the development of a standardized heat treatment procedure. Successful martempering requires the utmost in accuracy of temperature controls and indicators. Large sections which cannot be adequately cooled in 10 min. in salt should not be martempered. Generally the hardness obtained after martempering is slightly lower (½ to 1 point Rockwell C) than after oil quenching.

Some heat treaters have commented that the foregoing instructions sound like "kid-glove" handling of steel, and that if the steel were any good it wouldn't need such careful handling. This type of comment indicates a certain lack of appreciation of what may be termed the statistical factor in heat treatment. For example, there are many recorded instances where a number of identical tools made from the same stock have been processed and heat treated together, and a few tools in the group cracked while the majority were satisfactory. Investigation of tools that crack under these circumstances rarely produces any

*"The Interrupted Quench and Its Practical Aspects", by H. E. Boyer, A.S.M. *Transactions*, Vol. 38, 1946, p. 209.

Fig. 14 — Die, 8-In. Diameter x 2 In., Made of Manganese Oil Hardening Steel. Cracked by quenching from too high a temperature

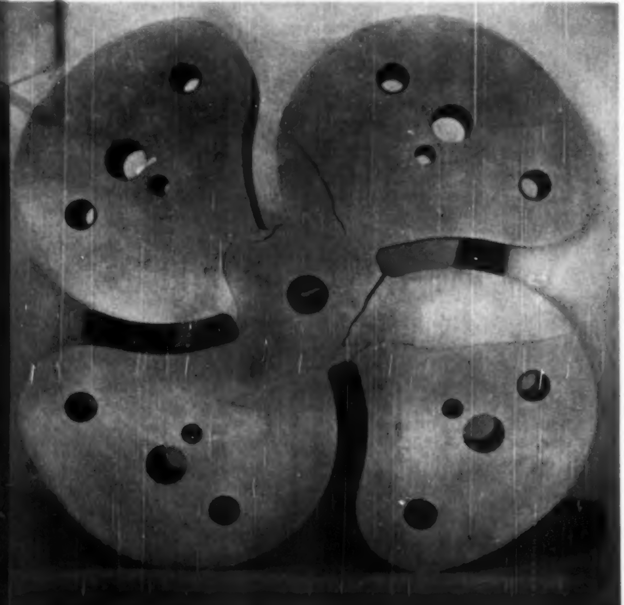
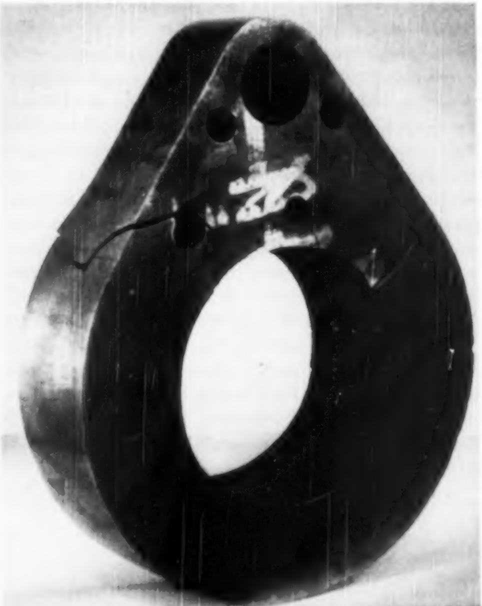


Fig. 15 — Cam, About 11 In. High, Made of Manganese Oil Hardening Steel. Cracked by quenching from too high a temperature



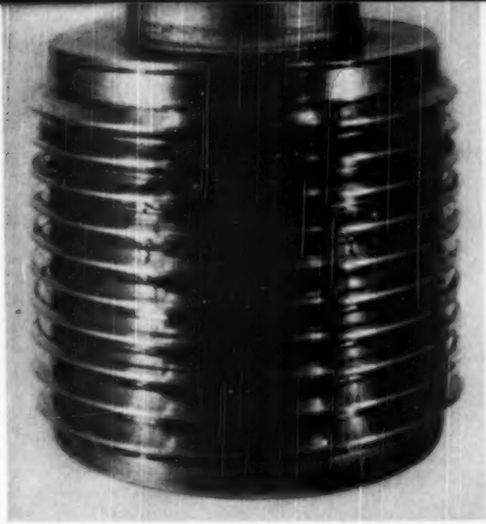


Fig. 16 — Plug Gage, 1⅛ In. Diameter x 2¼ In., of Manganese Oil Hardening Steel. Grinding cracks developed because of failure to temper after quenching

useful information, aside from the mere statistics. Unquestionably, a large percentage — possibly 90% — of tools *can* be successfully heat treated without following all the recommended practices. It is to avoid cracking the remaining 10% that careful preheating, quenching and tempering are required. Since it is obviously impossible to select in advance the tools most likely to crack, the only reliable procedure is to treat all units carefully.

Failure to temper immediately after quenching is the most frequent cause of trouble in heat treating. The heat treater who quenches tools one day and tempers them the next can expect a certain number of cracked tools (Fig. 11, 12 and 13).*

The second most frequent cause of cracking of tools in heat treatment is quenching from too high a temperature (Fig. 14 and 15). It is important to quench from the temperature range recommended for the particular steel and tool, because these recommendations are based on considerations of minimum cracking, as well as on the optimum formation of austenite before quenching. Equally important is the consistent use of pyrometric equipment that accurately indicates the temperature of the tools in the furnace.

The heat treater's responsibilities in regard to the use of correct quenching temperature and adherence to proper tempering technique go beyond the mere delivery of crack-free tools to the heat treat inspector. A tool improperly heat treated may be free from cracks but at the same time may be harboring high residual stresses that will cause cracks to form at the first application of a grinding wheel (Fig. 16 and 17).

*Figure numbers are continuous with those in the preceding article.

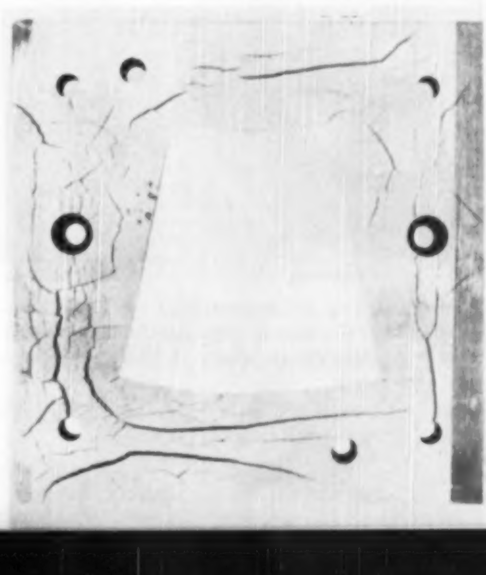
Differences in Steels — The tendency of tools to crack in hardening is greatly affected by the type of steel being used. Water hardening carbon toolsteel and manganese oil hardening toolsteel are most likely to crack if they are not handled properly. Air hardening toolsteels give practically no trouble due to cracking in hardening, and this is the main reason for their increasing popularity. If it were not for the relatively poor machinability of air hardening toolsteels, they would be more widely used than they are today.

In sections larger than 1 in., water hardening carbon toolsteel normally hardens with a case and core. This shallow hardening characteristic may cause two other types of cracking not encountered in oil or air hardening toolsteels:

1. Large sections of water hardening carbon toolsteel (larger than 4 in.) are particularly sensitive to cracking in heat treatment if the quenching operation does not produce a consistent and uniform chill on the tool. Soft spots on the surface may cause the steel to crack in the quench tank, after removal from the quench, or even in the tempering furnace. Cracking of this type may be violent enough to be classed as an explosion (Fig. 18). Soft spots may be caused by: *(a)* use of fresh water containing dissolved air, *(b)* use of contaminated water, *(c)* insufficient quantity of quenching solution, or *(d)* inadequate agitation. A drastic brine quench which produces a uniform chill is the cure for this type of difficulty.

2. A tool made from carbon toolsteel which has a section that will harden all the way through adjacent to one that does not harden all the way through is very sensitive to cracking in treatment.

Fig. 17 — Die Made of Manganese Oil Hardening Steel. Severely cracked in grinding because of sensitivity introduced by excessively high quenching temperature. Appearance of cracks has been exaggerated by magnetic particle test



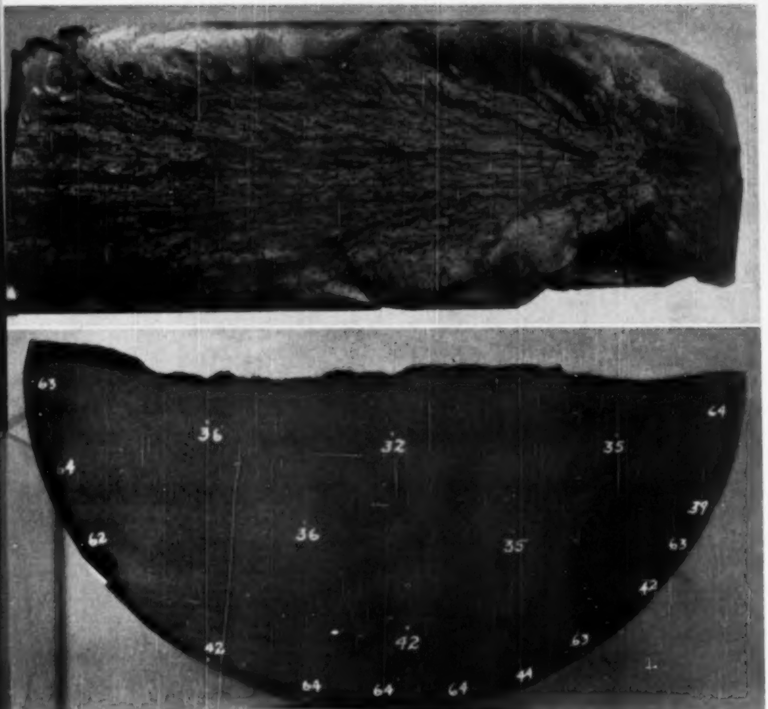


Fig. 18 — Roll Made of Carbon Toolsteel. Cracked during heat treatment because of nonuniform chill. Lower photograph shows a section of the roll etched to reveal chill. Numbers indicate Rockwell C hardness at the positions shown

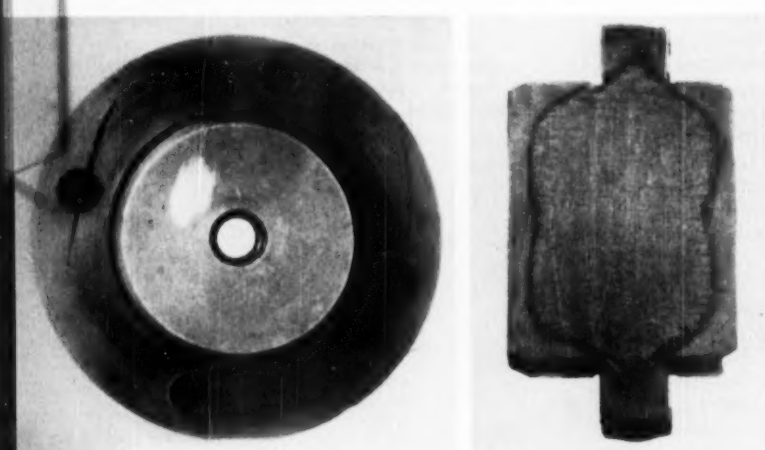


Fig. 19 — Die, 3 In. in Diameter, Made of Carbon Toolsteel. Cracked in hardening because of the fact that the rim hardened all the way through, as shown in macro-etched section

Either the tool should be redesigned or an oil or air hardening toolsteel should be used to avoid this difficulty (Fig. 19).

Simple Tests — In order to learn the most from toolsteel failures they must be analyzed fully to determine the basic cause of failure. It is improper to place the blame automatically on the operation where the trouble is encountered. Many toolmakers have no facilities for laboratory investigation of tool failures, but several simple tests will help in diagnosing such failures:

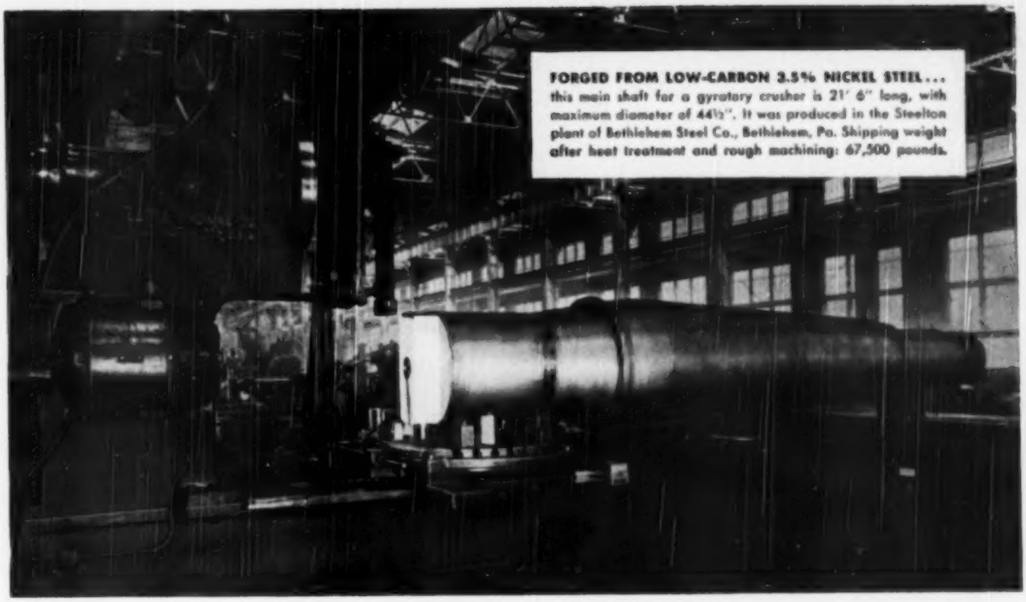
1. The spark test — observation of sparks from a grinding wheel — may show whether the correct grade of steel is being used, by comparison with known samples, and can also be used to detect heavy decarburization.

2. Fracture tests can be used as a check on the heat treatment of tools. Blanks treated with the tools can be fractured to indicate the response to the treatment used. Also, by quenching a series of small specimens one can determine the best quenching temperature and the optimum duration of holding under the actual conditions used for treating a certain tool. The examination of fractures of failed tools can also be informative. If temper colors are visible on the fracture it is definite that the crack was open during the tempering operation. If characteristic fatigue lines are visible, actual service stresses should be suspected as the cause of failure. A coarse fracture may indicate overheating during the hardening operation.

3. Hardness tests are obviously useful. If hardness testing equipment is not available, a file test by an experienced man can supply valuable information.

4. Either the magnetic particle test or cold nitric acid etch test can reveal grinding checks or treatment cracks in hardened tools.

(Distortion of tools in heat treatment will be considered in a later article by Mr. Riedel.)



FORGED FROM LOW-CARBON 3.5% NICKEL STEEL... this main shaft for a gyratory crusher is 21′ 6″ long, with maximum diameter of 44½″. It was produced in the Steelton plant of Bethlehem Steel Co., Bethlehem, Pa. Shipping weight after heat treatment and rough machining: 67,500 pounds.

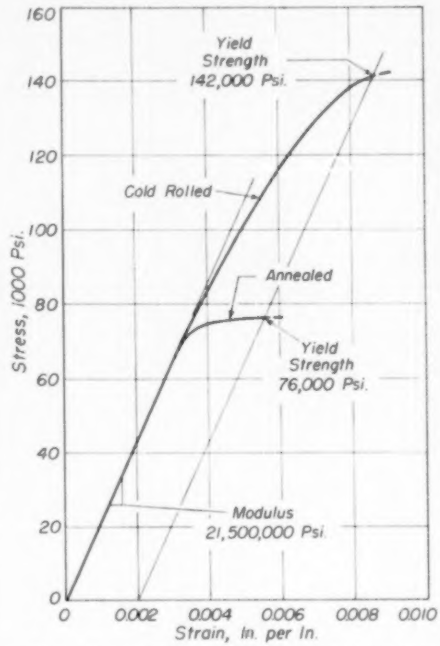
Properties of Vanadium Metal

By A. B. Kinzel, Electro Metallurgical Division, Union Carbide and Carbon Corp.

Physical Properties

Property	Value	Source
Atomic number	23	1
Atomic weight	50.95	1
Reported isotopes	47, 48, 49, 50, 51, 52	1
Crystal structure	Body-centered cubic	1
Lattice constant	3.034A	1
Density	6.11 g. per cu.cm.	3
Melting point	1710 ± 10° C.	3
Boiling point	3000° C.	1
Volatility at melting point	Very low	2
Specific heat (20 to 100° C.)	0.120 cal. per g.	2
Electrical resistivity	24.8 microhm-cm.	3
Temp. coeff. of resistivity	0.00280	2
Magnetic susceptibility	1.4×10^{-6} c.g.s.	1
Thermal expansion:		
23 to 100° C.	8.3 micro-in./in./°C.	3
23 to 500	9.6	3
23 to 900	10.4	3
23 to 1100	10.9	3
Modulus of elasticity	21.0 to 22.5 million psi.	3

Sources: (1) Metals Reference Book, Interscience Publishers, Inc., 1949. (2) J. W. Marden and M. N. Rich, *Industrial and Engineering Chemistry*, Vol. 19, 1927, p. 786. (3) Research Laboratories, Electro Metallurgical Div., 1949.

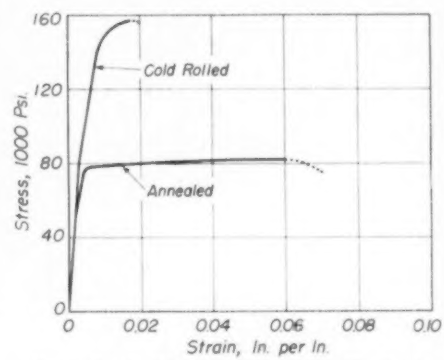


Stress-Strain Diagrams (High Magnification)

Corrosion Resistance

Corrodent*	Corrosion Rate, In. per Mo. As Rolled†	Corrosion Rate, In. per Mo. Annealed‡
10% HCl, 70° C., aerated	0.00072	0.00073
20% HCl, 70° C., aerated	0.0071	0.0045
20% HCl, 70° C., air-free	0.0123	0.0055
37% HCl, R.T., nonaerated	0.0029	0.0026
10% H_2SO_4, 70° C., aerated	0.00065	0.00059
10% H_2SO_4, 70° C., air-free	0.00036	0.00036
10% H_2SO_4, boiling	0.0048	0.0036
85% H_3PO_4, boiling	Dissolved	Dissolved
Dil. or conc. HNO_3, R.T.	Dissolved	Dissolved
5% $FeCl_3$ + 10% NaCl, R.T.	0.072	0.075
20% NaCl Spray, R.T.	No effect	No effect
Sea water	—	No effect

*Aerated = air bubbled through solution; air-free = nitrogen bubbled through solution; nonaerated = quiet solution, not saturated with either air or nitrogen. †Hardness, Rockwell C-27. ‡As-rolled metal held for ½ hr. at 1650° F. in vacuum; hardness, Rockwell B-93.



Stress-Strain Diagrams (Low Magnification)

Tensile Properties and Hardness

Condition	Prop. Limit, Psi.	Yield Strength, Psi.	Tensile Strength, Psi.	Elongation in 2 In.	Rockwell Hardness
Annealed 1 hr., 1500° F.	61,000	76,000	81,000	7%	B-76
Cold rolled 60%	63,000	101,000	107,000	1 to 2.5	B-92
Cold rolled 75%	68,000	110,000	117,000	1 to 2.5	B-95
Cold rolled 80%	69,000	142,000	155,000	1 to 2.5	C-29

Composition Limits

Element	Weight %
Oxygen	0.05 - 0.12
Hydrogen	0.001- 0.004
Nitrogen	0.02 - 0.04
Carbon	0.03 - 0.07
Vanadium	99.9 - 99.8

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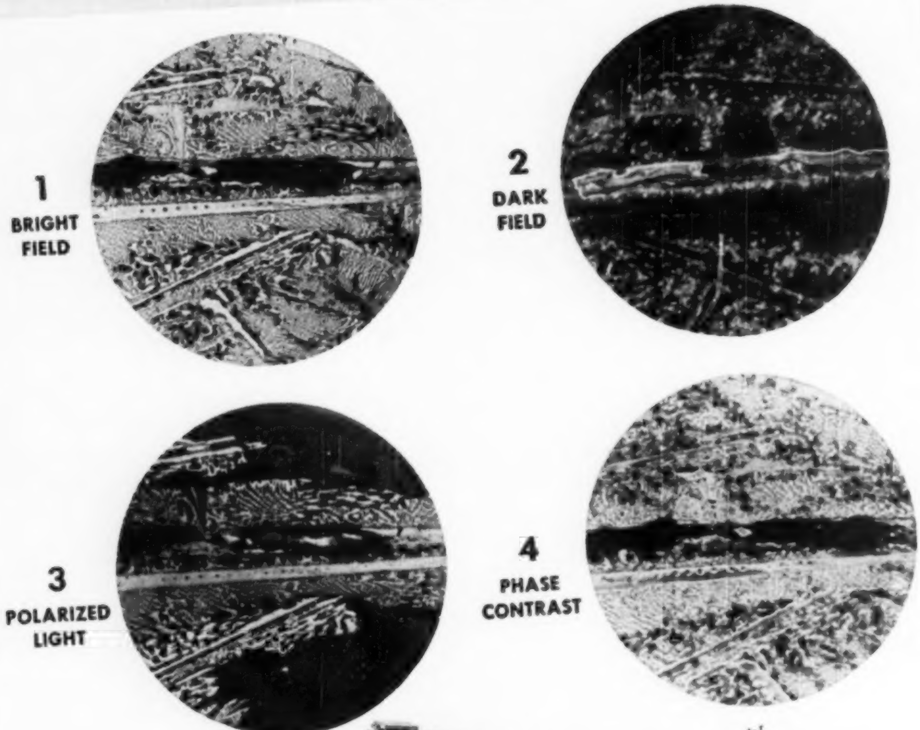
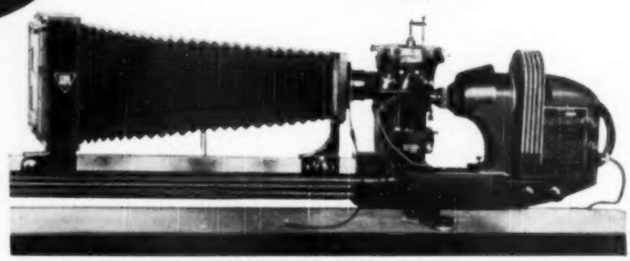


Photomicrographs of an unetched 15% manganese cast iron sample



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While condensed moisture alone will not tarnish nickel-silver articles in storage, slight contamination of acetic acid from green hardwood packing cases penetrated sealed plastic wrappings and pitted and discolored the metal badly during a spell of humid weather.

Tarnishing of Nickel-Silver

A FEW YEARS AGO trouble was experienced with the tarnishing of certain nickel-silver articles after several months' storage in outside depots, and (later) within our own factory before shipment.

The nickel-silver used was made to British standard specification B.S. 790, and contained 60 to 65% copper, 9 to 11% nickel and remainder zinc. The alloy was melted by us in Ajax-Wyatt induction furnaces originally using charges of electrolytic copper, nickel and zinc, and later, crop from foundry-cast ingots, as well as rolling mill process scrap from these charges, together with additional raw metals as required. Sufficient cupro-manganese was used as a deoxidizer to give a residual manganese of about 0.1 to 0.2%. The foundry-cast ingots were rolled and annealed to give strip of deep-drawing quality, which was afterward fabricated into the articles that developed the trouble.

The method of packing was as follows: The completed articles, which were about 2 in. long, 1¼ in. wide, and ⅜ in. thick, were individually packed in cellophane* envelopes, the seal being crimped and heat-sealed. One dozen of these envelopes were packed vertically in cardboard boxes, heat-sealed portion upward, and separated by interlocked cardboard dividing pieces. The lids of the cardboard box overlapped the sides completely, hence the tops and bottoms were protected by one layer of cardboard and the sides by two layers. When the cardboard boxes were closed, the heat-sealed and crimped portions of the envelopes were pushed down onto the top end of the metal articles they contained.

The cardboard boxes were then packed in wooden cases lined with bituminous sisalkraft paper. The packing cases were made from an Australian hardwood known as "Messmate" (*Eucalyptus obliqua*), and the construction of the cases was such that there was a quarter to half an inch spacing between edges of adjacent boards.

Examination of articles from a large batch which was returned from another state showed that, in a typical cardboard box, each article was tarnished but the tarnishing was confined to the top and sides only, and usually for about a quarter way down the length of the article. The corrosion film was generally yellowish-green, with small pits visible under a magnifying glass. Most pieces also had finger-print tarnishing. On their tops the tarnish stain reproduced the corrugated crimping of the heat seal of the cellophane envelope. Its color was spotty red-brown, similar to iron rust.

From the appearance of the articles and the damp feel of the cardboard boxes it appeared that water had entered the packing cases at some stage.

By A. L. Simmons
Senior Metallurgist
Australian Ammunition Factory
Melbourne, Victoria

*The word "cellophane" is not intended to signify any particular manufacturer's product, but is used as a generic term for transparent plastic of this well-known type.

One of the packing cases felt damp to the touch; the nails were rusty and there was a black stain in the wood around them. A gravimetric moisture determination on the timber showed 36% water, calculated on the dry weight.

A few days after the large batch had been returned, complaints were received from our factory storeroom that articles were tarnishing while awaiting dispatch. Examination of these showed precisely the same symptoms as described above, but in addition there were drops of water visible on the metal inside a few of the envelopes.

tannic acid in the wood), but it could not be said whether this was due to the use of green timber or to rewetting.

He also supplied some information on the electrical testing of wood for its moisture content. Special instruments are made for the purpose but quite satisfactory results are obtained by the use of an ordinary "Megger" tester (crossed-coil ohmmeter) such as used for testing insulation. It measures resistance; the higher the moisture content the lower the resistance. Two nails at ½-in. centers are driven halfway through a 1-in. board;

Conditions for Tarnishing of Nickel-Silver

Days	Moist Atmosphere	Moist Atmosphere Plus Acetic Acid	Normal Atmosphere Plus Vapor From Green Timber
1	Bright and lustrous.	One unenclosed sample slightly tarnished, with drops of moisture on it.	Bright and lustrous.
2	Bright and lustrous.	All unenclosed samples badly tarnished. Others under seal OK, except one near seal which was partly tarnished.	Two unenclosed samples tarnished; all others OK.
5	Bright and lustrous. Envelopes limp and felt damp.	All tarnished; unenclosed samples badly so, with drops of moisture on them. Envelopes limp and felt damp.	All unenclosed samples tarnished. Enclosed one just beginning to tarnish. Envelopes limp and felt damp.
7	Bright and lustrous. Some drops of water on article inside one envelope. Envelopes very limp.	Unenclosed samples very badly tarnished. All enclosed samples tarnished, but with some bright areas. Envelope very limp.	Unenclosed samples moderately tarnished. Enclosed samples all showed patches of tarnish but mainly bright. Envelopes very limp.
14	All samples bright and lustrous; free from tarnish. Water drops inside envelopes. Envelopes very limp.	As before. Unenclosed samples had green corrosion product and drops of moisture on them.	Much the same for samples in envelopes. Unenclosed samples had green corrosion product and drops of moisture on them.

Although it appeared from the returned articles that the boxes might have been wetted in transit, there was no possibility of this having occurred with those in our storeroom. This left either or both of two major causes:

(a) The packing case timber used was green.

(b) Condensation of atmospheric moisture.

J. M. West, a timber expert at the Government Munitions Laboratories, stated that properly seasoned timber in Melbourne would have a moisture content of about 12% in summer and 15% in winter calculated on the dry weight. Higher figures than these would indicate rewetting of seasoned timber or the use of green timber. In his opinion the rusting of the nails and the black stain in the wood around them was definitely indicative of wet timber (the black stain being due to the formation of an ink by reaction between the iron and the

the measurement is taken in the direction at right angles to the grain. Figures for Australian "Mountain Ash" *(Eucalyptus regnans)* apply fairly well to most other Australian hardwoods. Representative Megger readings versus moisture are:

0.4 megohms	26% moisture
1.0	21
4.0	18
15.0	15
40.0	13

Mr. West stated that green timber could contain as much as 60 or 70% moisture when cut from the tree and was liable to give off vapors containing acetic acid — hardwoods being worse than softwoods in this respect. In his opinion hardwoods should not be used for packing cases to contain metal articles.

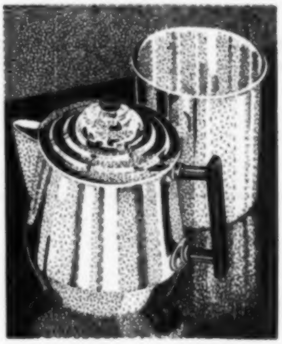
Inquiries made at the Meteorological Bureau showed that conditions prevailing in Melbourne

during the three mid-summer and mid-winter months are as follows:

SUMMER: Average maximum temperature 77.8° F.; average minimum temperature 56.1° F.; average relative humidity at 3 p.m. 50%.

WINTER: 57.1°, 43.0°, 64% respectively.

Routine temperature and humidity determinations made at the Munitions Factory showed that at about this time (July 1946) the daytime temperature was of the order 50° F., with humidities reaching 90% because of a very wet winter season. It also appeared that there was a distinct possibility that green timber had been used for the packing cases; in fact electrical tests on the packing cases of the articles which had tarnished in the storeroom showed moisture contents of up to 25%, and there was no possibility that this timber had been rewetted.



Acting on this information three series of laboratory tests were devised to investigate the following:

(a) Will the 10% nickel-silver tarnish in a moist atmosphere in the absence of acetic acid vapor?

(b) Will it tarnish in a moist atmosphere in the presence of such vapor?

(c) Will it tarnish in a sealed atmosphere containing green timber?

A sealed glass container was provided for each series. Corresponding with the letters above, *(a)* contained a saturated solution of sodium carbonate, giving a relative humidity of the order 90 to 95%; *(b)* also contained a saturated solution of sodium carbonate in one beaker and another a small beaker of glacial acetic acid; *(c)* contained a piece of the timber from the packing case which tested 36% moisture.

In each container the following samples were supported above the test corrodents:

1. Two polished articles, carefully cleaned, and unenclosed.
2. Two polished articles, carefully cleaned, then deliberately finger-marked, and unenclosed.
3. Two polished articles, carefully cleaned, each enclosed in a heat-sealed cellophane envelope and placed as close to the seal as possible.
4. Two, as for 3 above, but placed as far as possible from the seal.

The temperature of the containers was allowed to vary with inside ambient temperature conditions in order to simulate conditions in store and in transit. Although our buildings are normally heated during the daytime in winter, a fuel shortage had forced a shutdown of our furnaces during the winter of 1946. The test was allowed to run for two weeks, by which time sufficient information had been obtained, and then discontinued.

The results are given in the adjoining table, and led to several interesting conclusions:

(a) Exposure to a very moist atmosphere (90% relative humidity) for two weeks did not tarnish the nickel-silver even when corrosive conditions were accentuated by finger-marking and drops of water on the samples.

(b) A similar atmosphere with the addition of acetic acid vapor caused rapid tarnishing of a nature similar to that obtained on the sample submitted for examination. An atmosphere obtained from the packing case timber alone tarnished in the same nature but in lesser degree, indicating that acetic acid vapor from green timber was a primary cause of the trouble.

(c) The cellophane envelopes were not impervious to moisture, since droplets of water accumulated inside sealed envelopes. In the envelopes tested the seals appeared to be no less impervious to moisture than the remainder of the envelope.

(d) It was finally concluded that the tarnishing was due to a combination of acetic acid vapor and moisture derived from green timber and damp weather. Moisture condensed inside the packing cases during cold, humid nights in the storeroom, and normal ambient temperature variations in transit. In the summer (when the relative humidity was lower and the temperatures higher) condensation did not occur; in any case the timber would then have been drier.

In instances such as just described the tarnishing or corrosion of metal articles can be minimized by adopting the following precautions:

1. On no account should unseasoned timber be used for packing cases. The use of an electrical moisture meter for checking the finished cases will ensure this.
2. Use of hardwoods should be avoided.
3. Articles should be packed in a warm, dry atmosphere, and the contents of cases hermetically sealed — that is, in heat-sealed waxed or other impervious paper, or in soldered metal linings.
4. Packers should wear cotton gloves to avoid finger-printing the articles.
5. Do not rely on cellophane as a protection against moisture.

Sometimes bolted assemblies that are correctly designed and made of the proper alloy will fail because of variables in installation. Since malfunctioning is especially troublesome in equipment operating at high temperature, the authors studied the effects of repeated cycles of tightening, heating and cooling, and disassembly.

Superalloy Bolting Assemblies at 1250 and 1400° F.

GAS TURBINES, steam turbines and other devices operating at high temperatures usually are assembled with one or more flanged and bolted joints, so they may be taken apart readily for inspection or maintenance. The primary requirement of such a bolting system is that it retain sufficient elastic stress at the operating temperature to keep the joints permanently tight. Many studies have been made of the "relaxation stresses" of various bolting materials and an excellent summary has been published recently under the title "High-Temperature Bolting Materials", by E. L. Robinson, *Proceedings*, American Society for Testing Materials, Vol. 48, 1948, p. 214.

It is also necessary to be able to retighten and reassemble bolts and studs repeatedly without galling or fracture of the metal. Long experience with steam turbine installations has shown that this can be done with the ferritic metals commonly used up to 1000° F. Often, copper plating or proprietary anti-galling compounds are used to help in preventing seizure.

With the gas turbine and with steam turbines having inlet temperatures above 1000° F., it is necessary to use austenitic bolting of the "superalloy" variety. Although it is known that a number of these alloys have adequate relaxation strength up to at least 1500° F., not nearly so much is known about the ability of bolts made from the alloys to withstand repeated tightening and assembly operations. A paper by N. L. Mochel contributed to the American Society of Mechanical Engineers last year asks the following questions about bolts for these new high-temperature structures: "How susceptible are they to cracking at the root of the threads or under the heads? How tightly should they be pulled up? How brittle do they become in service? How many times may they be retightened?" All these questions are pertinent.

In general, the tendency for metals to gall or seize increases with increasing temperature. It is also well known that austenitic alloys seize more readily than ferritic grades. The austenitic materials with high relaxation strength are complex alloys that undergo phase changes and precipitation reactions at elevated temperatures. These metallurgical reactions may be of an embrittling character. It was also recognized that seizure could be inhibited by the use of anti-galling compounds, but the possible embrittling effects of these compounds were not known.

So much for the background of our study.

Test Materials — Five alloys were chosen as typical of the superalloy bolting materials currently available in wrought form:

19-9 DL — Chemical analysis: 0.30% C, 19% Cr, 9% Ni, 1.25% Mn, 1.3% Mo, 1.4% W, 0.4% Cb, 0.35% Ti. Form available: hot rolled and stress relieved for 4 hr. at 1200° F., air cooled.

Discalloy 24 — 0.03% C, 13% Cr, 25% Ni,

By C. T. Evans, Jr.
and E. J. Vater
Chief Metallurgist and Metallurgist
Elliott Co., Jeannette, Pa.

0.6% Mn, 0.9% Si, 3% Mo, 2% Ti, 0.15% Al. Solution treated 1 hr. at 1900° F., oil quenched, aged 20 hr. at 1200° F., air cooled. Hardness: Rockwell C-31.

Inconel X — 70% Ni, 15% Cr, 7% Fe, 1% Cb, 2.5% Ti, 0.7% Al. Available in two forms: Condition A — solution treated at 2100° F., air cooled, aged at 1550° F., air cooled, aged at 1300° F., air cooled; Rockwell C-30. Condition B — "equalized" at 1650° F., aged at 1300° F., air cooled; Rockwell C-36.

S590 — 20.5% Cr, 20% Ni, 20% Co, 0.4% C, 4% Mo, 4% W, 4% Cb, 1.5% Mn. Solution treated at 2200° F. 1 hr., water quenched, aged 16 hr. at 1400°F., air cooled.

Refractaloy 26 — 18% Cr, 37% Ni, 20% Co, 3% W, 2.7% Ti, 1% Si, 0.7% Mn. Cold finished, solution treated 1 hr. at 2100° F., oil quenched, aged 20 hr. at 1500° F. plus 20 hr. at 1350° F., air cooled. Rockwell C-31.5.

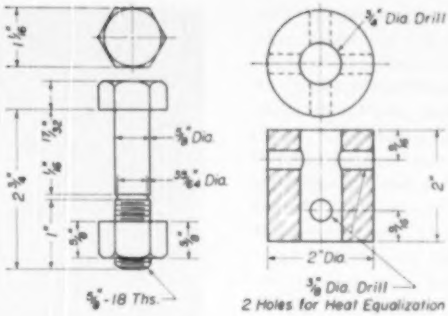


Fig. 1 — Dimensions of Bolts and Blocks for Test Assemblies; Inconel Washers Not Shown

Complete assemblies were machined from each material to the dimensions shown in Fig. 1. No attempt was made to achieve other than a standard high speed tool finish on the threads. The Inconel X parts were machined by the International Nickel Co. Hardened Inconel X washers 0.115 in. thick were used under head and nut in all tests, but otherwise each assembly had all parts made of the same material. Each piece was inspected for cracks visually and with fluorescent penetrant (Zyglo) before testing.

Test Procedure — Before assembly, the parts were scaled for about 4 hr. at the test temperature. The light oxide that forms helps to prevent galling. The threads on both the bolts and nuts, and all other bearing surfaces were then coated by brushing with one of two proprietary anti-galling compounds, which will be referred to as "silver paste" and "copper paste", since colloidal silver and colloidal copper were their principal constituents, respectively. Elliott Co.'s analyses of these compounds were as follows:

Silver Paste — 59.20% silver, 10.98% mercury, 4.62% lead, 25.20% pine oil (by difference).

Copper Paste — 26.43% copper, 17.95% graphite, 0.96% ash, 54.66% linseed oil (by difference).

After assembly, the nuts were tightened with a torque wrench to 110 ft-lb. Previous experiments at Elliott Co. had established that the average stresses put into 19-9DL assemblies with the silver paste is about 56,000 psi., and 22,500 psi. for S590 bolts. These figures, of course, do not take into account the large stress concentrations at the root of the threads or under the bolt head.

After tightening, each assembly was first

Fig. 2 — 19-9 DL Bolts Before and After Cycling 26 Times to 1250° F. Left to right: Unused bolt; bolt assembled with copper paste (threads in good condition); and with silver paste (threads in fair condition). About two thirds size

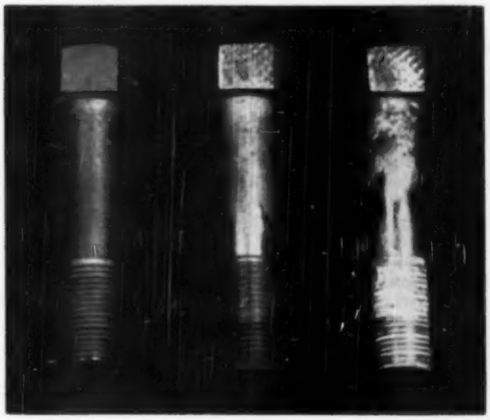
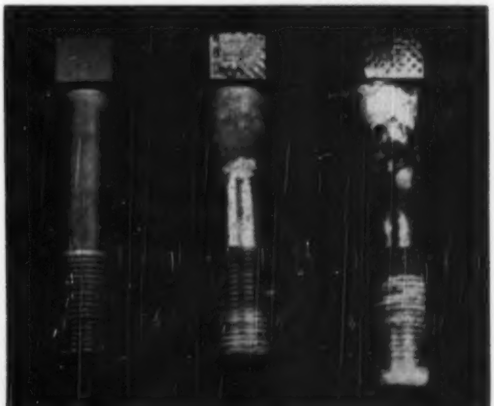


Fig. 3 — Inconel X and S590 Bolts Before and After Cycling to 1400° F. Left to right: Unused Inconel X bolt; Inconel X, silver paste, 26 cycles, no failure, threads in fair condition; S590, silver paste, could not be reassembled after 23d cycle, galled progressively, threads attacked below nut



given a 72-hr. cycle at the test temperature, with subsequent cycles averaging 24 hr. each until cracking or galling occurred or until at least 25 cycles had been experienced without failure. A test temperature of 1250° F. was used for 19-9DL, Discaloy 24 and Inconel X assemblies. S590, Refractaloy 26 and Inconel X were tested at 1400° F.

In most tests the assemblies were brought up to temperature as the furnace was heated. Sometimes the assemblies were placed directly in a hot furnace, but in no test was this procedure related to the cracking or galling noted. On cooling, the furnace was allowed to drop to at least 1000° F. before the assemblies were removed for cooling in still air.

After each cycle of heating and cooling the assemblies were taken apart, wire brushed, and occasionally accumulations of anti-galling compound on the plane surfaces were ground off. They were then recoated with the same anti-galling compound and reassembled to the same initial torque, with a steady pressure. Between cycles, several attempts were made to clean the threads sufficiently for good visual and fluorescent penetrant inspection, but this proved difficult and the attempt was abandoned. It was felt that the strains of disassembly and reassembly would be sufficient to crack completely any bolts which had reached a defective condition, and this proved to be true.

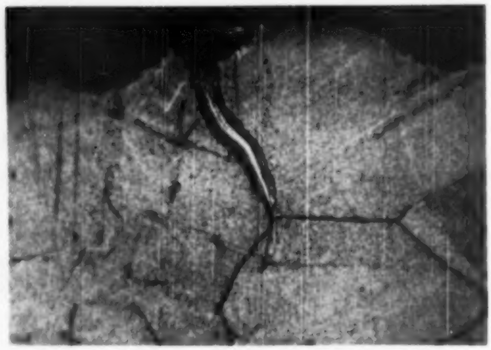


Fig. 4 — Longitudinal Section Through Inconel X Bolt A-2, Which Broke Through the Threads on Tightening for the 26th Cycle at 1400°F., With Silver Paste. Note grain boundary penetration. Etched electrolytically with 10% oxalic acid; 250×

Summary of Results — The results of these tests are recorded in Table I, below. The appearance of several of the bolts is shown in Fig. 2 and 3 on p. 349.

At 1250° F. only one bolt failed by cracking — Inconel X with the copper paste, after three cycles. This combination also failed at 1400° F. Other 1400° F. failures by cracking were Refractaloy 26

Table I — Bolt Assembly Cycling Tests at 1250 and 1400° F.

Alloy	Bolt Code No.	No. of Cycles	Anti-Galling Paste	Rockwell Hardness	Remarks
			Tests at 1250° F., With Torque of 110 Ft-Lb.		
19-9DL	19-9S	26	Silver	C-23	No failure; threads pickled in dilute nitric acid after 12th and 20th cycles; threads in fair condition.
19-9DL	19-9C	26	Copper	26	No failure; threads in good condition.
Inconel X	A-1	26	Silver	34	No failure; threads in good condition.
Inconel X	B-1	26	Silver	38	No failure; threads in fair condition.
Inconel X	A-3	3	Copper	31	Broke through threads on tightening for 4th cycle.
Discaloy 24	D-1	26	Silver	31	No failure; threads in fair condition.
Discaloy 24	D-2	7	Copper	31	Started to gall on 5th cycle; could not be assembled after 7th cycle.
			Tests at 1400° F., With Torque of 110 Ft-Lb.		
S590	S-S	25	Silver	36	No failure; threads attacked below nut after 5th cycle; threads pickled after 12th and 21st cycles.
S590	S-C	25	Copper	36	No failure; threads in good condition.
Inconel X	A-2	25	Silver	30	Broke through threads on tightening for 26th cycle; threads in fair condition.
Inconel X	B-2	26	Silver	31	No failure; threads in fair condition.
Inconel X	A-4	4	Copper	26	Broke through threads on tightening for 5th cycle.
Ref'loy 26	R-1	26	Silver	30	No failure; threads in fair condition.
Ref'loy 26	R-2	5	Copper	30	Broke through threads on tightening for 6th cycle.

Notes: Number of cycles includes initial cycle of 72 hr. at temperature; subsequent cycles averaged 24 hr. each. Torque of 110 ft-lb. is equivalent to about 56,000 psi. for 19-9DL and about 22,500 psi. for S590, both with silver paste. Hardness measured at room temperature on side of hexagonal bolt head after cycling test.

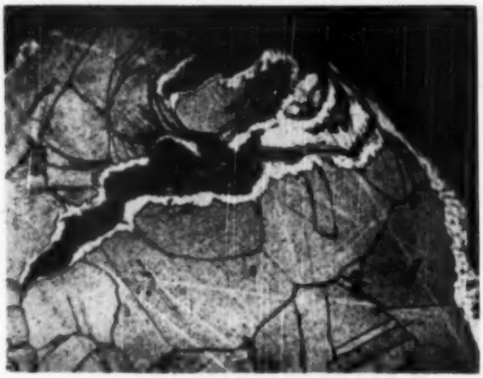


Fig. 5 — Same as Fig. 4, at Corner. Note surface layer as well as grain boundary penetration; 200×

with copper paste, after five cycles, and Inconel X in the fully heat treated condition with silver paste after 25 cycles. All the crack failures occurred in the bolt threads between nut and head. Discaloy 24 bolt with copper paste could not be assembled after seven cycles. On the other hand, 19-9DL threads with copper paste were in better condition after 26 cycles than with silver paste. This is shown by the center bolt in Fig. 2.

Likewise, at 1400° F., S590 threads were in better condition with copper than with silver paste. An S590 bolt with silver galled progressively and could not be assembled after 23 cycles, and an identical assembly at lower torque also galled quite badly. This compound also appeared to corrode the S590 bolts in the area below the nut, as shown by the right-hand bolt in Fig. 3.

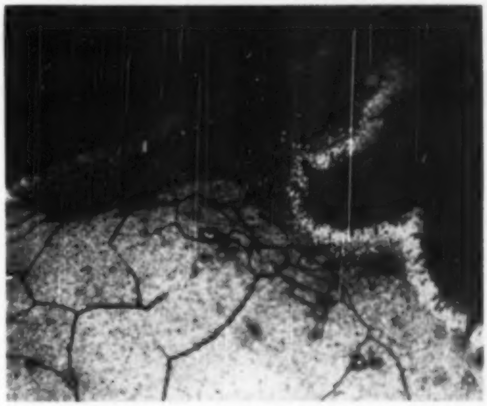
In general, the assemblies with silver paste were more difficult to take apart after cycling than the assemblies with copper paste.

The only comparison of different heat treatments for a given material is for Inconel X bolts assembled with silver paste at both 1250 and 1400° F., but the data are not sufficient to justify conclusions. The fully heat treated material gave a better thread condition at 1250° F. than the bolts equalized and aged, but it was the fully heat treated specimen which cracked after 25 cycles at 1400° F.

Cause of Cracking — The bolts that cracked seem to have done so because of the intergranular penetration of anti-galling compound of the metal. This mechanism is illustrated in the micrographs, which also show surface layer and diffusion phenomena that may or may not be related to the cracking and galling observed.

It was thought that the 26th-cycle failure observed for Inconel X might be at least partially the result of progressive internal embrittlement of the metal itself, without any outside influence. Accordingly, tensile tests were made on the remainder of the failed piece and compared with results obtained with a test bar from an unused bolt having the same heat treatment. The results indicated no internal embrittlement — in fact, the heat-cycled piece had the higher ductility in the tension test.

Fig. 6 — Longitudinal Section Through Inconel X Bolt A-4 at Corner, Which Broke Through the Threads on Tightening for the Fifth Cycle at 1400°F., With Copper Paste. Etched electrolytically with 10% oxalic acid; 250×. Note surface layer, diffusion effect and grain boundary penetration. At other locations, grain boundary penetrations quite similar to Fig. 4 were observed



Conclusions — Probably the only general conclusion that can be drawn from this exploratory work is that each combination of bolting material and anti-galling compound should be thoroughly tested at the expected operating temperature and initial torque level before placing any reliance on the assembly. In other words, the importance of the problem is confirmed by our experiments.

Other indications from these few tests are as follows: *(a)* A proper combination of superalloy bolting material and anti-galling compound will withstand at least 25 reassembly cycles of 24 hr. each and service up to 1400° F. without failure by cracking or galling, provided the anti-galling compound is replaced between successive cycles, and *(b)* when cracking occurs, it is apparently caused by intergranular penetration of the bolt material by the anti-galling compound.

For 1020 steel, shot peening markedly reduced the temperature of transition from ductile to brittle failure, as measured by slow bend tests of notched specimens.

Effect of Shot Peening on the Brittle Transition Temperature

ONE of the useful properties of many metals is their ability to deform permanently before fracture. This is referred to as ductility, and the opposite behavior is called brittleness. These are not intrinsic properties; under suitable conditions a metal may pass from one state to the other. Unfortunately there is no single test or measurement that will uniquely determine this composite property. The condition of mechanical stability is defined by the following parameters: *(a)* composition and structure of the material, *(b)* state of stress (triaxiality), *(c)* strain rate, and *(d)* testing temperature. Because of the dependence on strain rate, ductility (or brittleness) is a dynamic property of the material.

One effective experimental evaluation is to determine the conditions under which the metal will pass from a ductile to brittle behavior. For ferritic steels this demarcation is well defined. The usual experimental technique in studying a given metal is to keep the triaxiality and strain rate constant and to determine the temperature where the metal will become brittle. This temperature is called the brittle transition temperature, corresponding to the given triaxiality and strain rate.

Specimens — In the present study the effects of shot peening on the transition temperature of a mild steel were investigated. A bar of 1020 steel (0.20% C, 0.37% Mn, 0.009% P, 0.028% S) was cut into pieces 6 in. long and fully annealed at 1650° F. for 1 hr. After the surface scale was removed, a semicircular notch ¼ in. deep with ⅛-in. radius was milled in the center of one side (Fig. 1). The specimens were then divided at random into three batches: One batch was used as control specimens, the second batch was shot-peened to an intensity of 0.013 on the Almen gage No. A2 and tested in that condition, and the third batch was shot-peened to the same intensity as the second, then stress relieved at 450° F. and subsequently tested.

Testing Procedure — A detailed description of the apparatus and the experimental technique has been given previously,* and only a brief outline is included here. The testing equipment is designed to load a specimen in simple bending at a given uniform speed and temperature and to supply a load-deflection record of the test. Electric strain gages (AB-7, SR-4) connected in a bridge circuit are used to measure both the load and deflection. The integral parts of the apparatus include the loading machine with strain gages, the thermocouple and millivoltmeter, stop watch, electronic recorder and a still camera.

The loading device is a lever system which

*"De Forest Brittle Temperature Research", by P. R. Shepler, *Welding Journal, Research Supplement*, V. 25, No. 6, June 1946, p. 321s to 332s; "The Effect of Welding Technique in the Brittle Transition Temperature", by N. Grossman and P. R. Shepler, *Welding Journal, Research Supplement*, V. 26, 1947, p. 321s.

By Nicholas Grossman
Assistant Professor of Mechanical Engineering
Massachusetts Institute of Technology
Cambridge

transmits the load to the specimen resting on a suitable support. The support, specimen and electric strain gages are housed in a subzero test cabinet which can be cooled to −100° F. by forced circulation of dry ice; the specimen can be further cooled by pouring liquid nitrogen around it.

An a-c. bridge system is employed whereby a 5500-c.p.s. voltage is introduced into the load bridge and the deflection bridge, with the resulting unbalance from loading or deflecting detected, amplified and transmitted to a 3FPI tube. A record is made with a still camera. The load bridge and the deflection bridge contain an AB-7, SR-4 strain gage in each of the four arms.

The notched test specimens were freely supported on knife edges 5½ in. apart with the notch in the middle of one side perpendicular to the longitudinal axis. The load was applied in the center of the bar on the side opposite the notch.

The specimen was first cooled to a temperature that was estimated to be slightly above the transition temperature. If the load-deflection record showed a departure from linearity when the load was applied at a constant deflection rate at this temperature, it was an indication that yielding had occurred and that the specimen was still in the ductile condition. The test was then stopped and the same procedure was repeated at a lower temperature. This "probing" was continued until the first specimen failed with a very slight amount of yielding. A new specimen was then tested at the same speed but at a lower temperature to eliminate the possible effects of the cold working of the first or probing specimen. This procedure was repeated until the exact transition temperature was determined.

If the first test had shown a brittle failure, the second specimen would have been tested at a higher temperature. The advantage of starting above the transition temperature is that the first specimen can be used for several trials before it fails.

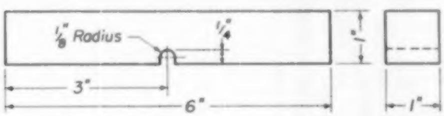


Fig. 1 — Dimensions of the Test Specimen

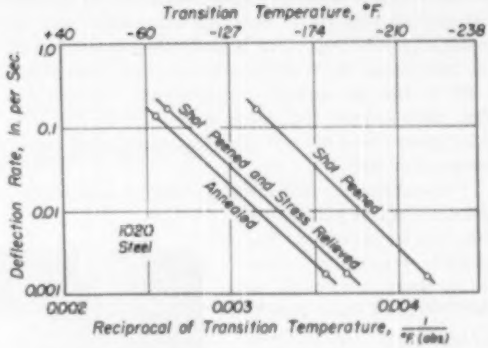


Fig. 2 — Transition Temperature Versus Deflection Rate for Slow Bend Tests of Notched Specimens

The transition temperature determined in this way is the highest temperature, at a constant strain rate, for which the metal ceases all macroscopic ductile behavior as revealed by the load-deflection curve.

Discussion of Results

It has been known for some time that, with a given metal and system of constraint, a straight line is obtained when the logarithm of deflection velocity is plotted against the reciprocal of absolute temperature of transition. This property was utilized in the present investigation. The plotted curves in Fig. 2 indicate that shot peening made the steel more ductile, as reflected by a decrease in the brittle transition temperature. This decrease was most drastic on the shot-peened specimens tested

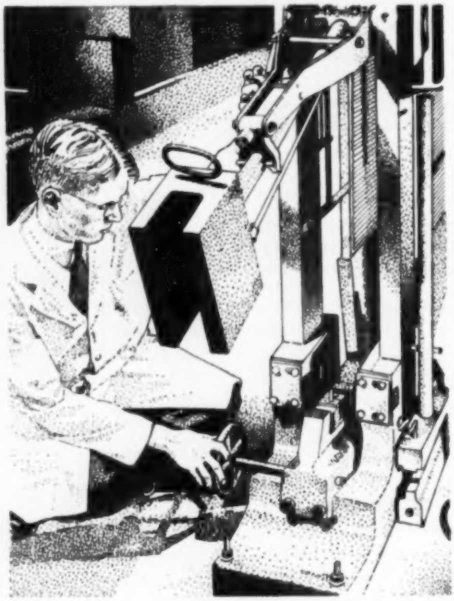
Table I — Results of Experiments on 1020 Steel

	Annealed Only		Shot Peened		Shot Peened and Stress Relieved at 450° F.	
Transition temp. Deflection rate*	−70° F. 0.137	−180° F. 0.00171	−145° F. 0.164	−220° F. 0.00170	−80° F. 0.164	−190° F. 0.00150
Surface roughness	19 micro-in.		70 to 85 micro-in.		70 to 85 micro-in.	
Monotron hardness						
Average	25.5 kg. (8)†		26.5 kg. (10)		28.0 kg. (11)	
Range	25.0 to 26.4		25.0 to 29.8		26.5 to 32.0	
Rockwell superficial hardness						
Average	30T-46.3 (6)†		30T-50.0 (7)		30T-49.9 (7)	
Range	38 to 50		44 to 55		47 to 54	

*Deflection rate in in. per sec. †Figures in parentheses designate total number of readings, of which the average is given.

without any subsequent heat treatment; specimens stress relieved *after* shot peening were not so markedly affected. For a deflection rate of 0.10 in. per second the transition temperature was about −80° F. for the annealed specimens, −150° F. for the shot-peened test bars, and −95° F. for the specimens shot-peened and subsequently stress relieved at 450° F.

According to our present state of knowledge, fracture starts just below the surface where the highest triaxiality exists — in these specimens, at the root of the notch. Evidently the fracture did commence at the layer where the metal was cold worked due to peening. Two conclusions may be tentatively drawn: *(a)* Shot peening introduces a highly compressed surface layer, and if fracture is to initiate within this layer, the transition temperature of the part is decreased — indicating that the metal is in a more ductile state as a result of peening; *(b)* stress relieving of the specimens after shot peening removes most of these effects.



To get some possible correlation with other mechanical properties, the hardness of the surface was measured. Care had to be exercised, however, to insure that only the topmost metal layer was considered and evaluated. The Vickers hardness tester is not suitable because it requires a well-defined, sharp indentation, not readily obtained on a peened surface. The Monotron hardness tester, based on the principle that the required load (in kilograms) to penetrate a given constant depth (0.0018 in.) is the measure of hardness, was well adapted to the shot-peened specimens. As a qualitative check the Rockwell 30-T hardness was also determined. The data obtained reveal no correlation between hardness and transition temperature. Although heating the shot-peened specimens to 450° F. markedly influenced the value of the transition temperature, it scarcely affected the hardness, as indicated in the lower part of Table I.

Shot peening introduces compressive stresses into the surface layer. It has been estimated that the depth of the stressed layer, as revealed by X-ray diffraction patterns, is about 0.006 in. for a steel and peening intensity comparable with those reported here.* During the present investigation two other methods were tried to establish the depth of the hardened layer, as well as to gain a quantitative estimate of the degree of cold working introduced by the peening operation.

Several shot-peened test bars were placed on the surface grinder and with the aid of sine-bars the specimens were tilted a small angle and the shot-peened surface ground to a depth of about 0.1 in. through a horizontal distance of about 2½ in. This gave a 25-fold "vertical magnification". The surfaces were then prepared for metallographic examination. It was hoped that the distorted grains close to the surface would be well differentiated from those unaffected by the cold working and that the demarcation zone would give positive information as to the depth of penetration. Unfortunately this approach did not yield the results that were significant.

Another method was then tried: By the use of the Bierbaum Microcharacter several sharp scratches were made on the tapered surfaces with a diamond indenter and a known load. However, this method was not sensitive enough to differentiate the cold worked and unaffected portions.

Summary

Shot peening of annealed 1020 steel markedly decreased the temperature of transition from ductile to brittle failure under the given conditions. Stress relieving at 450° F. increased the transition temperature of the shot-peened specimens nearly to the value for the original annealed steel. No correlation could be observed between surface hardness and change in ductility.

*"The Effect of Shot Blasting and Its Bearing on Fatigue", by J. M. Lessells and W. M. Murray, *Proceedings*, American Society for Testing Materials, V. 41, 1941.

Correspondence

Russian Research in Arc Welding

BUFFALO, N. Y.

In the June issue of *Metal Progress*, among the five abstracts of Russian articles is one on which this Laboratory conducted the original research: "Multi-Arc Welding of Thin Sheet". This Laboratory not only has the patents on the Multi-Arc process but has registered the name.

The first publication on this subject is found in the supplement to the *Journal of the American Welding Society*, Vol. 9, July 1944. Several publications in different journals on various phases of Multi-Arc welding have been published subsequently. United States patents have been granted to this Laboratory covering the circuit, the method of welding, the torch, and the apparatus. In the abstract, the sketch of the welding torch is identical to ours, except that a star has been added to the welder's glove.

About 1948, before the United States Government issued the no-sale order of equipment to Russia, this Laboratory sold Russia two complete Multi-Arc welding outfits, including torches and literature pertaining to design and use. From the timing of the Russian article these have probably been busy since their arrival in the Soviet Union.

From the abstract in *Metal Progress* a reader could gain the impression that this was original Russian research. Although the abstract does not state this claim precisely, we wonder if the article makes any such claim.

L. W. SMITH
Head, Metallurgy Section
Cornell Aeronautical Laboratory, Inc.

Abstracter's Reply

The author of the Russian paper, K. V. Zvegintseva (a woman), makes no claim to originality — and no reference to American work. The Russian paper describes a study of the multiple-arc welding process as applied to thin sheets of stainless steel. The article referred to by Mr. Smith is entitled, "A Paper on Multi-Arc Welding of Aluminum Alloys", by Malcolm R. Rivenburgh and C. Weston Steward, both of Curtiss-Wright Corp., Buffalo, N. Y. No mention is made of welding alloys other than aluminum and, although the process described is the same as that in the Russian paper, there is not so much detail given concerning manipulation. Both articles refer to the fact that five arcs are in operation. The U. S. patents, granted to Steward and Rivenburgh and assigned to Cornell Aeronautical Laboratory, are as follows:

Method of welding	2,437,840	(1948)
Welding apparatus	2,478,985	(1949)
Welding circuit	2,479,087	(1949)
Welding torch	2,512,509	(1950)

Rapid Tests for Intercrystalline Corrosion

NANCY, FRANCE

The rapid methods for determining susceptibility of aluminum alloys to intercrystalline corrosion described in February 1950 *Metal Progress* by Hugh L. Logan deserve wide use, in view of my similar findings in the laboratory of Prof. G. Chaudron in Lille and Paris during the years between 1927 and 1933 when I was preparing a doctorate thesis. In our basic experiment two small strips of duralumin were immersed in a 3% NaCl solution and electrolyzed with 0.0001 amperes per sq.cm. of direct current at 2-volt potential for 48 hr. The resulting attack was quite superficial. The cathodic strip was unaffected in strength and ductility, but the anodic strip lost one quarter of its original tensile strength and three quarters of its elongation.

I concluded that small amounts of chlorine are harmful to this alloy and cause quite rapid, selective attack along intergranular paths.

Later, as we studied corrosion of various light alloys in sea water, we used this rapid method to select those resistant to intercrystalline corrosion.

We compared rapid and slow methods of attack, namely, *(a)* anodic attack, *(b)* oxygen under 35 psi. or higher pressures, *(c)* alternate dry and wet tests in 3% NaCl solution, and *(d)* long immersion in sea water.

Our results were published in *Comptes Rendus* for June 1933, wherein we stated that aluminum alloys containing up to 7% magnesium (with less than 0.15% silicon and low in iron) are very resistant to sea water when the metal is in the fully annealed state. Moreover, pure aluminum (99.7% Al plus), the 1% manganese alloy (American alloy 3S), and aluminum alloys with 2 to 3% magnesium and 0.5 to 1% manganese are not subject to intercrystalline corrosion in sea water. However, Al-Mg-Si and Al-Cu alloys rapidly lost their elongation and tensile strength (that is, suffered intergranular corrosion) after immersion in 3% NaCl solution, 48 hr. of anodic attack, 120 to 150 hr. exposed to high-pressure oxygen, 45 days of alternate wet and dry tests, and six months' immersion in natural sea water.

Mr. Logan finds that immersion in $NaCl + H_2O_2$, as required by Army-Navy Specifications, is likely to cause pits which confuse the result — a statement which checks our earlier conclusions. Minute amounts of H_2O_2 can be detected during normal corrosion of aluminum alloys in the presence of oxygen under atmospheric pressure, but this is far below the amount existing in the above test solution. This pitting action is especially severe in aluminum alloys containing copper. For these reasons Professor Chaudron and I did not recommend the accelerated hydrogen peroxide test, except when used with great circumspection and for checking the slower natural field tests.

Eugene Herzog
Pompey Steel Works

Mr. Logan's Reply

I am pleased to note that Dr. Herzog used a similar method on Al-Mg and Al-Mg-Si alloys. I had suggested that the method be used on Al-Cu-Mg-Mn and Al-Zn-Mg-Cu alloys. The electrolytic method was proposed as a time-saving device, not because the $NaCl-H_2O_2$ solution would fail to indicate correctly whether or not given samples of the alloys indicated above were susceptible to intercrystalline corrosion. In a recent paper [*Journal of Research of the National Bureau of Standards,* July 1948] Harold Hessing and I have reported good agreement between the results of stress-corrosion tests on bare high-strength aluminum alloy sheet in the laboratory by continuous immersion in the $NaCl-H_2O_2$ solution and by exposure in a marine atmosphere at Hampton Roads, Va.

"Green Rot" of Electrical Resistors

London, England

Nickel-chromium alloys were the first successful resistance elements for electrically heated devices, and their use has been extremely widespread. Adaptability for such applications is ordinarily measured by rate of scaling in air. However, many uses at present expose the metal to flue gases or to prepared atmospheres containing much carbonaceous gases; typical are electrical resistors in gas carburizing furnaces, containers or carriers in heat treating furnaces, gas turbine blades and combustion chambers. In certain of the latter applications nickel-chromium alloys may deteriorate at a rapid rate by a phenomenon sometimes called "green rot".

Messrs. Dovey and Jenkins of British General Electric Co. have studied this matter, exposing various alloys at temperatures between 1650 and 1800° F. in a controlled atmosphere for bright annealing of mild steel, and in another adapted to the gas carburizing process. X-ray examination of the corrosion products indicated that the main constituent was chromic oxide, associated with a small concentration of nickel oxide. Tests for sulphur were negative. Metallographic examination indicated simultaneous carburization and oxidation.

In a report of their investigations recently made to the Institute of Metals they say that carburization leads to a reduction of the effective concentration of chromium in the matrix (as a result of carbide precipitation), to an extent dependent upon the carburizing potential of the furnace atmosphere and upon the solubility of carbon in the matrix. The chromium carbides thus formed are susceptible to oxidation, and, when they are present at grain boundaries, rapid intergranular oxidation of the alloy occurs in depth.

Approximately 2% silicon in a nickel-chromium-iron resistor alloy is sufficient to prevent carburization in atmospheres containing both carburizing gases (propane) and combined oxygen (CO). Dovey and Jenkins suggest that 2% titanium may confer some resistance to carburization in such atmospheres. However, a 2% silicon alloy carburizes readily in an atmosphere containing hydrocarbons but free of oxygen-containing compounds, provided there is no superficial oxide film.

The inhibiting effect of silicon may be associated with the nature of the oxide film on the alloy. This effect may be confined to the interface between metal and oxide in the form of a barrier film rich in silica, and may be due to some ability of silica to seal rifts in the oxide layer.

Tom Bishop

Nodular Cast Iron Produced With Li, Ca, Ba, Sr, Na

GHENT, BELGIUM

We now know that the elements cerium, magnesium, lithium, calcium, barium and strontium can produce nodular cast iron. In 1948, H. Morrogh published a remarkable study on the production of nodular iron with cerium. A short time later (February 1949), independently of each other and almost simultaneously, A. P. Gagnebin and C. K. Donoho announced their work on the production and properties of nodular cast iron through treatment with magnesium. That same month, I reported positive results not only with magnesium but also with lithium. At the International Foundry Congress at Amsterdam, in the autumn of 1949, I discussed the first results obtained with calcium (inconclusive, because near well-formed spherulites, the iron also contained supercooled graphite). We first used an alloy of copper and calcium; since that time considerable success has been noted with pure calcium, alloys of calcium, and even with calcium salts as, for example, $CaCl_2$. More recently nodular cast iron has been obtained with the addition of barium and strontium.

The micrographs in Fig. 1 show the structure of nodular cast irons made using lithium, calcium, barium and strontium, the order of sequence from left to right in Fig. 1 corresponding to the chronological order of our satisfactory laboratory results with these four elements.

My hypothesis (published in the *American Foundryman* for January 1949) concerning the influence of silica particles in suspension in liquid cast iron on graphite crystallization, and their elimination by strong deoxidation in the production of nodular cast iron, was useful in guiding our research toward effective utilization of the elements lithium, calcium, barium and strontium. Even sodium was partially successful (Fig. 2). Of course these results are not conclusive, but they represent an argument of some value.

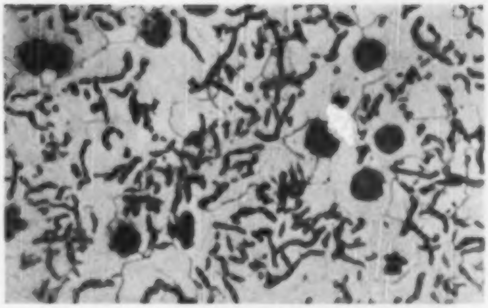


Fig. 2 — Cast Iron Treated With Sodium, Showing Spherulitic and Wormy Graphite. 300×

While mentioning the effects of various elements, it may be noted that the role of sulphur still needs elucidating. We do not know whether there is always a cause and effect relation between desulphurization and the appearance of spherulites. For instance, spherulites have been obtained with rather high contents of sulphur and tellurium.

A. L. DE SY
Professor of Metallurgy
University of Ghent

With Lithium; 200 × With Calcium; 100 × With Barium; 200 × With Strontium; 250 ×

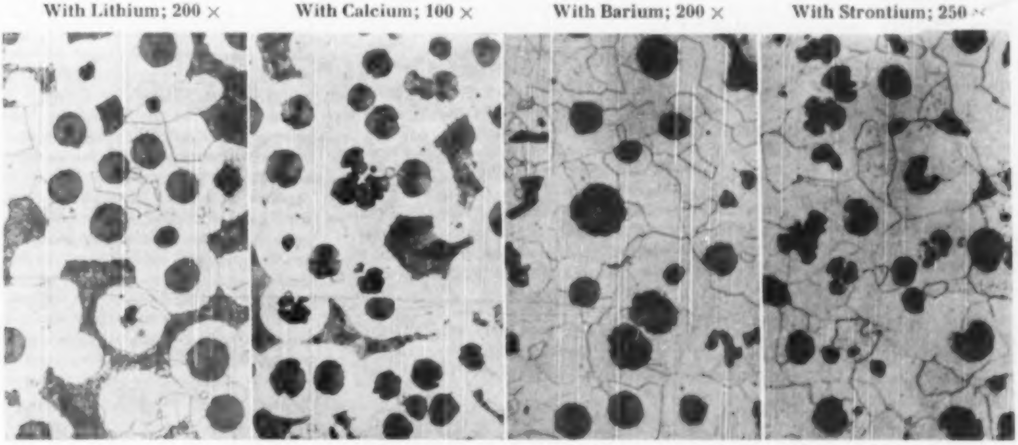


Fig. 1 — Nodular Cast Irons Produced With Lithium, Calcium, Barium and Strontium

Personal Mention

Earl Chester White

A young graduate of the University of Michigan entered Henry Ford's employ 23 years ago, and since then has engaged in a wide variety of metallurgical activities in that unique organization — starting, more or less naturally, in the analytical laboratories, but soon getting out into the Rouge steel plant and devoting his attention to problems in the various departments and finally to manufacturing research in steelmaking. During the war **Chester White** was supervisor of metallurgy for supercharger manufacture, and later was transferred to Canton, Ohio, where he has been chief metallurgist of Ford's recently built forging plant. He is now manager of chemical engineering of the new Ford-Mercury automatic transmission plant in Cincinnati. This deceptive title includes metallurgical supervision of heat treatment operations, physical testings, and technical control of machine shop, stamping shop and finishing operations.

After receiving his Ph.D. from the University of Utah in June, **John P. Denny** has joined the General Electric Co., Schenectady, as a research associate.

Vernon G. Berkey, a 1950 graduate from Missouri School of Mines and Metallurgy, is now an assistant metallurgist with Armco Steel Corp., Rustless Div., Baltimore, Md.

Walter E. Littmann, who graduated from the University of Cincinnati in June, has accepted a fellowship at Massachusetts Institute of Technology, Cambridge, Mass.

Richard Byron has left the employ of Republic Steel Corp. to join the C. H. Byron Co., industrial painting and sheeting contractors.

Charles S. Barrett

The Franklin Institute has named **Charles S. Barrett** to receive its Francis J. Clamer Medal for meritorious achievement in metallurgy. Dr. Barrett was among the first American investigators to employ X-ray diffraction systematically in the study of metals, and his contributions to X-ray metallography during the past 25 years have been a major factor in the development of metal science in this country. The importance of his studies to industrial metallurgy is most evident in his contributions on deformation and aging, which are alluded to in the citation that accompanies the Clamer Medal: "In recognition of his outstanding contribution to the knowledge of crystal structures and of the effects of deformation and aging on various metallic crystals." Dr. Barrett is a native of Vermillion, S. D., and was awarded his B. S. degree by that State's University. He received his Ph.D at the University of Chicago, was in charge of the X-ray work at the Naval Research Laboratory from 1928 to 1932 and at Carnegie Tech from 1932 to 1946. Since 1946 Dr. Barrett has been active in research at the Institute for the Study of Metals of the University of Chicago.

Eugene P. Klier has been appointed to the task of organizing a department of metallurgy at the University of Maryland, College Park.

Clark B. Carpenter

Extraordinary breadth of interest characterizes **Clark Carpenter**, head of the department of metallurgy at Colorado School of Mines. The most recent evidence is election to the presidency of Sigma Gamma Epsilon fraternity — which is not, as one might suppose, an undergraduate student society, but an organization of scientists and teachers working in the "earth sciences" — mining, geology, seismography, metallurgy — of which he had been secretary-treasurer for 25 years. Carpenter came to Golden with the aid of two canes in 1920, direct from a World War I hospital, and has been building the metallurgical department ever since. In that first decade he also had time and ability to act as professor of coal mining, and to nurse a single lecture series into a full-fledged course. "I managed to escape from the coal mining department", says Carpenter, but this experience helped in a later adaptation of petroleum coke to cupolas and lead blast furnaces. During World War II he directed some studies on the heat treatment of armor piercing shot. His current metallurgical interests are the intensely practical features of the iron foundry; he had a part in developing the first high-strength cast iron made in the Rocky Mountain area, and is now watching with interest the production of nodular iron.

John B. Saxton is now employed as a materials engineer at the Detroit Arsenal.

Personals

Wyckoff Steel Co. announces the appointment of **Angus G. Sturrock** as manager of the metallurgical division of the company. He has been with the company for 22 years. **Edsel Bishop**, formerly with the Carnegie-Illinois Steel Corp., has been named metallurgist for the Ambridge, Pa., plant.

E. Lancashire is now head of process inspection at Union Metal Mfg. Co., Canton, Ohio.

After graduating from Rensselaer Polytechnic Institute in June 1950, **Paul L. Mitchell** has accepted a position as chemist at the Philadelphia laboratory of the E. I. duPont de Nemours & Co., Fabrics and Finishes Division.

James P. Bruner, who graduated from Michigan State College in June 1950, is now working as analyst in the research division of Armco Steel Corp., Middletown, Ohio.

L. Gillette Lawrence, formerly project engineer on light-weight equipment for American Car and Foundry Co., is now associated with the research and development department of the Pullman-Standard Car Mfg. Co. as the light-metals metallurgist in the materials division.

Dan Campbell is now employed as a tool engineer for Almquist Bros.

James W. Noble, a June 1950 graduate of Carnegie Institute of Technology, is now with Vulcan Crucible Tool Steel Co., Aliquippa, Pa., as metallurgist.

James L. Oberg has been transferred by Babcock & Wilcox Co. from the Barberton, Ohio, works to the New York office where he will be a sales engineer, specializing in process equipment.

Wilton F. Melhorn, formerly assistant professor of metallurgy at Virginia Polytechnic Institute, has accepted a graduate assistantship at the University of Cincinnati.

Robert E. Hebert has been recently employed as a metallurgist at the Watervliet, N. Y., plant of Allegheny Ludlum Steel Corp.

Andrew C. Batten has been appointed assistant test engineer in the welding laboratory of the American Car and Foundry Co., Berwick, Pa.

Frank L. Muro has accepted a position as metallurgist for the Joy Mfg. Co., Claremont, N. H., upon graduation from Pennsylvania State College.

Following graduation from Missouri School of Mines and Metallurgy, **Charles E. McGaughey** is now a trainee with Mid-Continent Steel Casting Corp., Shreveport, La.

Robert E. Christian has recently been employed by Allegheny Ludlum Steel Corp., Brackenridge, Pa., as cost control man on metallurgical processes.

G. Fred Simmen, Jr., a recent graduate from Grove City College, is now with the Beckwith Machinery Co. as sales engineer.

Neng-Kuan Chen, who received his doctor's degree from Yale University this last June, is now a research associate in metallurgy at Johns Hopkins University, Baltimore, Md.

J. F. Kuzmick, formerly with Ekstrand & Tholand, is now president of the recently organized Welded Carbide Tool Co. and is also engaged in a consulting practice in the powder metallurgy field.

Personals

Carnegie-Illinois Steel Corp. announces that **Ralph W. Dickson** has been named division superintendent of the central mills. He has been associated with the Gary works since June 1927.

Benjamin F. Street, Jr., has recently been promoted to power salesman in the suburban division for Philadelphia Electric Co. He joined the company 13 years ago and has progressed through the positions of retail salesman, cooking specialist, and air conditioning engineer to his present status.

Philip E. Schneider, who graduated from Drexel Institute of Technology in June 1950 as a member of the first class to graduate in metallurgical engineering from that Institute, has been appointed assistant metallurgist in the production department of the Rustless Division of Armco Steel Co., Baltimore, Md.

W. S. Touchman is now chief engineer for Vacu-matic Carburetor Co., Wauwatosa, Wis.

Paul B. Parker, who was formerly with the Corps of Engineers writing specifications and engineering reports, is now with Deere & Co.'s materials engineering department.

A. S. Jenkins, Jr., a June 1950 graduate of Virginia Polytechnic Institute, is now employed as metallurgist at the Bureau of Mines, Eastern Experiment Station, College Park, Md.

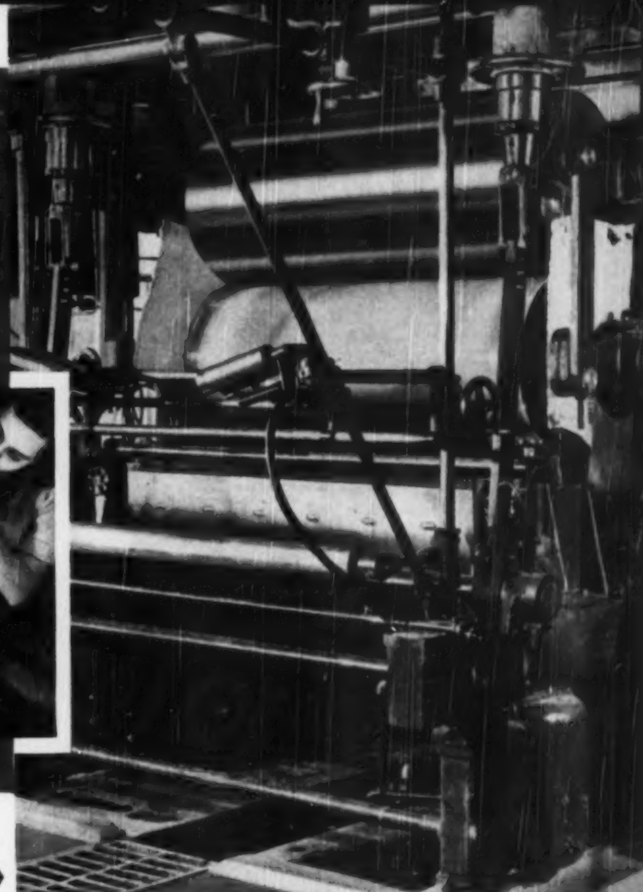
A. P. Gloeckler, formerly standards engineer on the central staff of AVCO Mfg. Co., is now chief metallurgist at the New Idea Div. of AVCO at Coldwater, Ohio.

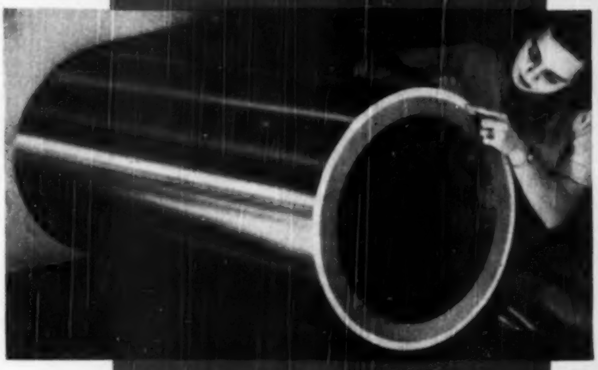
Wayne A. Reinsch has recently joined the engineering department of Chance Vought Aircraft Co., Dallas, Tex., as metallurgical engineer.

Royden C. Presley has been transferred by Allegheny Ludlum Steel Corp. from manager of the Toledo, Ohio, district sales office to manager of the Birmingham, Ala., area.

The following A.S.M. members have recently joined the metallurgical staff of Oak Ridge National Laboratory, Oak Ridge, Tenn.: **Leonard A. Abrams, Melvin J. Feldman, Peter Patriarca,** and **Joseph C. Zukas.**

DUAL METAL DOES IT AGAIN!





TWO METALS ARE BETTER THAN ONE—Dual Metal textile roll . . . stainless steel outside, metallurgically bonded to a gray iron core, rough machined and ready for shipment from our plant.

ONE ROLL WITH A DOUBLE ROLE! This three-roll heavy duty padder made by the Morrison Machine Company with the dual metal rolls top and bottom and rubber-covered iron roll in the middle is used by the textile industry to impregnate and squeeze many fabrics.

Take, for example, the casting of the rolls we make for the Morrison Machine Company of Paterson, New Jersey, one of America's leading designers and builders of textile machinery.

Two metallurgical characteristics are needed—an outer shell that resists corrosion from bleaches, finishes and dyes, *plus* an inner core that makes for economy and ease in fabricating.

No *one* metal can do both economically. So utilizing centrifugal force and temperature, the two dissimilar metals are poured successively in horizontally spinning metal molds. The casting thus has an outer shell of stainless steel metallurgically bonded to an inner core of gray iron.

Result? A vastly superior roll . . . *one* that combines *two* metallurgical properties into a single structural unit and makes possible a heavier, more rigid roll at lower cost!

Today we are supplying single and dual metal cylindrically shaped castings to an ever increasing list of progressive equipment builders.

Centrifugal castings may be the answer to *your* problem. In any case, why not find out? Write today and tell us what you're up against. We may be able to help.

[illegible]

[illegible] Steel—all AISI Types, plus special heat and [illegible] analyses.

Alloy Steel—all grades.

Carbon Steel—all grades.

Gray and Alloy Iron — all standard and special [illegible].

Dual Metal—[illegible]

SIZE RANGE

Outside Diameter—[illegible] through [illegible]. Wall Thickness—[illegible] to 4". Lengths—Up to [illegible].

U. S. PIPE AND FOUNDRY CO.

SPECIAL PRODUCTS DIVISION

BURLINGTON, NEW JERSEY

AMERICA'S LARGEST PRODUCER OF CENTRIFUGALLY CAST FERROUS METAL PRODUCTS IN TUBULAR FORM

Personals

Arthur B. Tesmen, formerly with North American Philips Co., Inc., has joined Tempil° Corp., New York City, as sales engineer.

William Klaile, president of William Klaile Machine Shop, has been elected president of the Newark, N. J., Bank of Commerce.

Jessop Steel Co. announces that **Frank B. Rackley** has been elected president of the company. Mr. Rackley joined Jessop Steel in 1948 as general manager of sales, and since has been promoted to vice-president in charge of sales and executive vice-president.

Charles W. Vigor, who graduated in June from the University of Michigan, has entered the employ of the Research Laboratories Division of General Motors Corp., Detroit.

La Salle Steel Co., Hammond, Ind., announces the appointment of **M. G. Sladek** as district sales supervisor in Minnesota, Iowa, Wisconsin and most of Illinois and Ohio. He has been with La Salle in a sales capacity for the past seven years.

Braeburn Alloy Steel Corp. announces the appointment of **Kenneth A. Stroble** as general sales manager with headquarters at Braeburn, Pa. Mr. Stroble was previously western New England sales manager.

Atlantic Steel Co., Atlanta, Ga., announces that **F. A. Teeple, Jr.,** has been appointed manager of its newly established product engineering department. He has been with Atlantic Steel since 1934 in various engineering and executive capacities. He will be assisted by **Fred O. Reese**, **Emmett R. Rushin, Lawrence A Wallace**, and **Michael F. Wiedl, Jr.,**

Following graduation from Carnegie Institute of Technology, **Albert C. Coulson** has accepted employment as a practice engineer at the Steubenville, Ohio, works of Wheeling Steel Corp.

Frank J. Miller, formerly research assistant and equipment engineer in the department of metallurgy at Case Institute of Technology, is now equipment engineer at Los Alamos Scientific Laboratory, Los Alamos, N. M.

Nothing takes the place of Chromel Alumel thermocouples

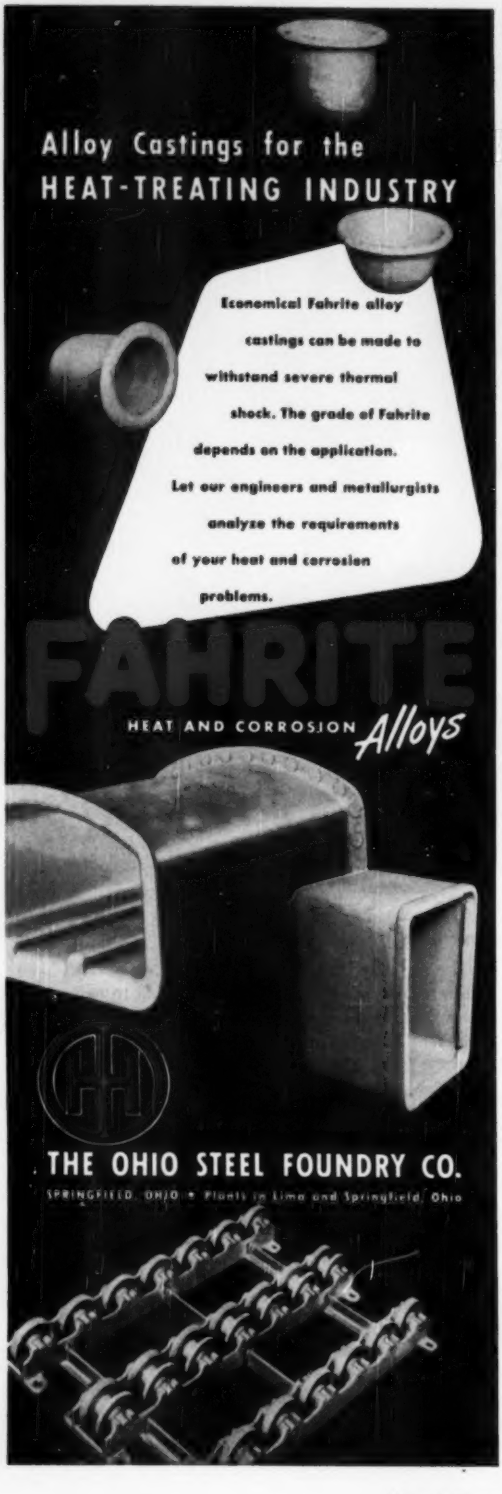
When you're working with heat between 1000° and 2000° F. and accurate temperature measurement is essential to the results you want to produce, you'll find there is no suitable substitute for Hoskins CHROMEL-ALUMEL thermocouple alloys. They're unconditionally guaranteed to register true temperature—E.M.F. values within very close specified limits. Exceptionally durable . . . so resistant to oxidation that you need not pack the protection tube. Hence, highly responsive to temperature fluctuations. And, in spite of hard use, they maintain their fine degree of accuracy over far longer periods of time than any other known base metal thermocouple materials.

So for positive long-life assurance of accurate temperature measurement, insist that your pyrometers be calibrated for CHROMEL-ALUMEL thermocouples. And important, too . . . be sure you use CHROMEL-ALUMEL *extension* leads instead of so-called "compensating" wires. For, when the couple and the lead are of identical alloy compositions there is no possibility of "cold-end" errors. Our Catalog 59-R contains a complete technical explanation . . . want a copy?

CHROMEL-ALUMEL couples and leads are available through your instrument manufacturer or pyrometer service company . . . ask for them by name!

HOSKINS MANUFACTURING COMPANY
4445 LAWTON AVE. • DETROIT 8, MICHIGAN
NEW YORK • CLEVELAND • CHICAGO
West Coast Representatives in Seattle, San Francisco, Los Angeles
In Canada: Walker Metal Products, Ltd., Walkerville, Ontario

**the [illegible] ickel-chromium resistance alloy that first made electrical heating practical*


Alloy Castings for the
HEAT-TREATING INDUSTRY
Economical Fahrite alloy castings can be made to withstand severe thermal shock. The grade of Fahrite depends on the application. Let our engineers and metallurgists analyze the requirements of your heat and corrosion problems.
FAHRITE
HEAT AND CORROSION Alloys
THE OHIO STEEL FOUNDRY CO.
SPRINGFIELD, OHIO • Plants in Lima and Springfield, Ohio


Let
Spincraft
SKILL WILL DO IT
put the heat on tooling costs
Investigate this organization that may help you shape design to ever lower costs of production.
Spincraft can be an indispensable aid in your drive for lower costs of production . . . for Spincraft engineering has been pioneering developments in working metals that were not even dreamed of two or three years ago.
Unless you are aware of these revolutionary advances and their significance to cost ratios, you may be working with inadequate knowledge of what spinning can and will do for you today.
If you have a part that is round or only in part rounded, check Spincraft before you tool-up or reject an idea as too costly. Your inquiry is invited regardless of size or metal — and substantial savings may be your reward.
Spincraft Inc.
SKILL WILL DO IT
4137 W. State Street
Milwaukee 8, Wisconsin
Heretofore known as Milwaukee Metal Spinning Co.
TRANSMISSION HOUSING
Combining a cone and a hemisphere — made of 10 gauge cold rolled steel. The length of this housing is over 30 inches.
TELEVISION TUBE
Spinning made of 1/8-in. thick chrome iron — 446 stainless steel — a material previously considered non-formable by any method. The diameter of this tube is 16 inches.
The new Spincraft data book is yours for the asking — a helpful, fact-full reference bulletin that may accelerate your design ideas.
Spincraft — serving large and small industries everywhere — is the world's largest and most versatile metal spinning plant.
CORONA SHIELD
Combining spherical and hemi-spherical spinning — made of 250 aluminum 1/8-in. thick.
The overall length of this piece is over 20 inches.

HIGH PRODUCTION

in an

EMERGENCY

THE METAL INDUSTRY is awake to the need for increased production. It will meet the challenge as it has done in the past.

The 32nd Annual National Metal Congress and Exposition comes at a most appropriate time. At this all-important meeting of the top management, production and engineering talent in the industry, more than 30,000 will be in attendance.

If you haven't already planned to be in Chicago for the Metal Congress and Exposition—do so NOW! You will gain much by meeting people in the industry with similar problems—by seeing first hand what's new and improved to aid you in increasing your production.

This will be one of the most important meetings in the history of the metal industry. Top management men will be able to meet and talk to others—to compare notes, and to gather helpful information that would take weeks to secure in any other manner. And that goes for production men—department managers, supervisors, superintendents and foremen. All will be looking and listening—to get as much information as possible in a short space of time. And time is important right now. Engineers and metallurgists will be there to see what's new in equipment and processes, to examine and learn about structure and properties of new materials, that will fit into their operations and enable them to quickly step up production.

There will be about 400 firms displaying their products and services, with trained men in attendance to answer your questions and explain how they can help you achieve HIGH PRODUCTION.

Four great societies sponsor and participate in the Metal Congress and Exposition.

The American Welding Society will hold technical sessions at the Sherman Hotel, Monday through Friday.

The Institute of Metals Division of A.I.M.E. will hold technical sessions Tuesday, Wednesday and Thursday at the Sheraton Hotel.

The Society for Non-Destructive Testing will hold technical sessions on Tuesday, Wednesday and Thursday at the Morrison Hotel.

The American Society for Metals has a full week—Saturday through Friday—of technical sessions to be held at the Palmer House. "High Production" Sessions will be held at The Amphitheatre. If you would like a complete program of the Metal Congress, write American Society for Metals, 7301 Euclid Avenue, Cleveland 3, Ohio.

Chicago is centrally located and within reach of the entire metal industry. Plan now to attend this great meeting. There are ample hotel accommodations—write Chicago Convention Bureau, Inc., 33 N. LaSalle Street, Chicago 2, Ill.

Attend the Metal Congress and Exposition and you'll take back information that will enable you to do your job better and help your company do its share in this emergency.

32nd

NATIONAL

METAL CONGRESS

AND EXPOSITION

International Amphitheatre, Chicago, Ill.

OCTOBER 23-27, 1950

Russian Metallurgical Journals

(Starts on p. 331)

most recently, since the Soviets have lost all their "friends" among the Western powers, the tables of contents have been just plain Russian.

In 1932, a sixth journal devoted to ferrous metallurgy was started, "Urals Metallurgy" *(Uralskaya Metallurgiya)*. Its articles were of a practical slant, often very interesting. Most of them, of course, reflected the specific needs of the Urals district. This journal disappeared in December 1940.

From today's point of view, the most important journal which made its appearance in the early 1930's is "Factory Laboratory" *(Zavodskaya Laboratoriya)*. Although the name does not indicate it, this is a predominantly metallurgical journal; it covers the fields of analytical chemistry, physical and mechanical testing of metals, as well as chemical and metallurgical laboratory apparatus. Fortunately, this journal has survived the various purges, although it discontinued publication between July 1941 and December 1944. The content of "Factory Laboratory" is practical and, with the possible exception of the papers on home-made laboratory apparatus, holds considerable interest outside Russia today. In 1950, however, only a few exchange copies seem to have come through.

In 1933, a seventh journal for ferrous metallurgy appeared in Moscow, "Quality Steel" *(Kachestvennaya Stal)*. It was attractively made-up, and carried interesting, practical, original articles that were relatively short and often written from fresh, if controversial, viewpoints, dealing exclusively with alloy steels and ferro-alloys. Personally, I liked it best because most of the papers were so brief and to the point. When this fine journal was in its sixth year, the by now well-known ax fell and we have the tragicomic picture of a journal whose editors were so utterly unaware of their impending fate that in the very last issue, on the very last page, they printed a set of instructions on how to prepare papers intended for publication in their journal!

So much for the strictly metallurgical journals. There are many others that carry research papers on metallurgy, chiefly the physical and chemical publications of the Academy that are shown in the illustration below. Specialized periodicals in other branches of technology also print articles of interest to metallurgists. For instance the field of refractories is ably covered by "Refractories" *(Ogneupory)*, which was started in Moscow in 1933. The content of this journal is theoretical as well as practical and, as a rule, on a creditable level. Each issue contains a few papers on combustion engineering, but that subject has lately been taken over by the journal "Oxygen" *(Kislorod)*. Started in Moscow as a bimonthly, while the war was still on, in 1944, it covers all phases of the use and transportation of oxygen and, in particular, it contains research data on the use of oxygen in both the steel and nonferrous metals industries.

(Continued on p. 370)

These Seven Journals of the Academy of Sciences of the U.S.S.R. Occasionally Contain Papers of Interest to Metallurgists. The titles translated are: (left) Journal of Applied Chemistry and Journal of Technical Physics; (center) three sections of the Bulletin of the Academy of Sciences of the U.S.S.R. — Physical Series (at top), Technical Science, and Chemical Science; (right) Journal of Physical Chemistry, and Reports of the Academy of Sciences of the U.S.S.R. The Journal of Experimental and Theoretical Physics and the Acta Physicochimica belong in this picture but copies were not available for photographing. Three of the journals shown are now on the "oversubscribed" list, as are the two not shown.

Russian Journals

(Starts on p. 331)

Although the editorial in *Metal Progress* for June stated that scant information is available on Russian machining practice, there *is* a Russian journal devoted entirely to machining practice and theory and it is still coming in strong. The name of this journal is *Stanki i Instrument*, usually translated "Machine Tools and Instruments", although "Machine Tools and Hand Tools" would probably be more accurate. In earlier years, the level of the contributions was nothing to get excited about, but their quality has been visibly improving of late. This journal publishes the Soviet standards on hand tools and machine tools after they have received official sanction. The whole gamut of cutting and grinding operations is covered; there are also valuable papers on chip formation, surface finish and methods of appraising it, and related topics. Each volume contains a small number of papers concerning the metallography and heat treating of toolsteels, and problems of machinability are dealt with. This journal pays close attention to new developments reported in *American Machinist* and *Machinery*.

The journals mentioned so far have been more or less thoroughly abstracted in this country. There exists also a whole flock of highly specialized journals relating to metallurgy, modeled after the German house organs. The following deserve mention: "Central Bureau for Ferrous Metals" *(Glavchermet)*, "Southern Metallurgy" *(Yugomet)*, "Urals Metallurgy" *(Uralmet)*, each serving one of the so-called trusts. There were also special magazines for the blast furnaces in Sverdlovsk, the coke plants in Kharkov, the auxiliary rolling-mill machines in Sverdlovsk, and so on. Whether or not these magazines have survived the last war, I do not know; however, two years ago there was published by the Stalin KM Works a "Collection of Scientific-Technical Papers" on ferrous metallurgy, and a similar symposium must be credited to the Ilyich Works in Mariupol (Southern Russia). Lesser plants have issued small mimeographed bulletins with technical information. For example, the metallurgical works in Chusovaya (Urals Dis-

(Continued on p. 372)

Russian Journals

(Starts on p. 331)

trict) publishes the "NITO Bulletin" (NITO is short for Society of Engineers and Technicians of the Chusovsk Metallurgical Works). At least a quarter of the 19 issues which appeared in 1946 and 1947 is devoted to papers on steel melting, 10% on the blast furnace, 25% on rolling. There are also a great many original research data — for example, on vanadium slag. The entire volume of papers contains 403 pages with 159 illustrations.

Production Figures — It is, of course, well known that no Russian journal publishes gravimetric or volumetric data on production for stated periods of time. Even the weekly or monthly publications of individual works or trusts never state how many tons of pig iron or steel were produced and what the yields were. About all they say is that plant A has fallen short of, or exceeded, the production goal by so many per cent.

In contrast to the custom of other countries, "production" — at least in the years preceding the last war — was, for instance, the quantity of metal run out of a furnace without regard to its soundness or suitability; thus, "production" included all the scrap and rejects. At the rolling mill, "production" was what went into the mill in the form of ingots or blooms, and not what came out of it. Another example will illustrate this even better: An order had been issued to the tractor plant in Stalingrad to produce 40 tractors per day. So day after day, 40 tractors left the sheds; maybe one of them could move out under its own power; the rest were pulled out and then finished outside the gates. Thus was the "production goal" reached!

At the time when the heavy industries were started, production figures of this kind, of course, gave an entirely wrong picture of the situation. There can be no doubt that, in the years 1929 to 1933, the production figures published were not attained. In the years after 1933 until about 1937, however, the figures published were more likely to reflect actuality, and after March 1937, the opposite procedure was adopted and figures published were

(Continued on p. 374)

Russian Journals

(Starts on p. 331)

lower than those actually reached.

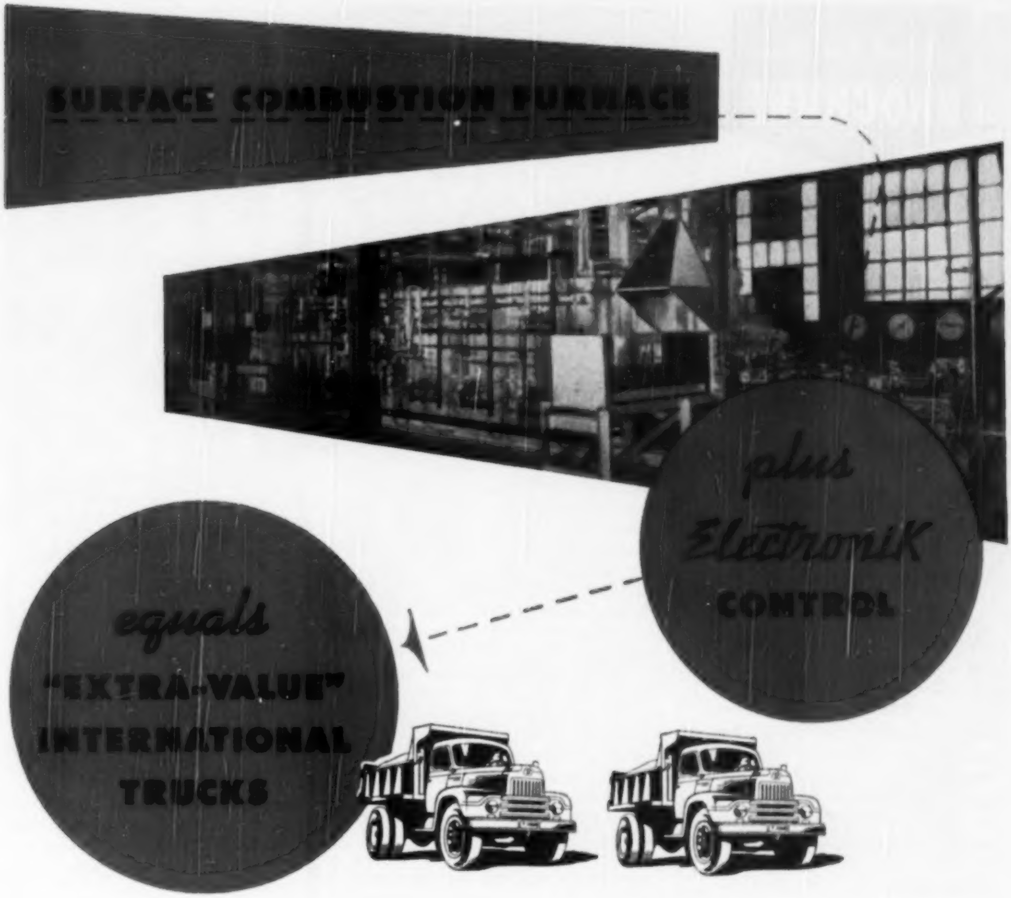
In the summer of 1941, the German High Command released a reference book in which the capacity of the Russian industry was detailed for the different branches; there were data on the capacity of the furnaces, the plants, the number of workers, and so on. This book had been compiled on the basis of such data as had been published previously in the Russian technical literature. When German experts entered Russia in the wake of the German armies (and this information comes from one of those experts) they found that, in actuality, production was considerably *higher* than indicated in their reference book and that the potentials calculated on the basis of their lists were wrong.

Another example of the element of surprise and mystery concerns wire-drawing dies. On Nov. 28, 1941, a German committee on wire drawing was in session and (according to the minutes) it developed that Russia had placed an order for multiple wire-drawing machines to be operated at such high speeds that the well-known Krupp Widia dies used in them simply could not stand the pace. The Russian purchasing commission, however, was not surprised at all and hinted that maybe they had the right die material and, at any rate, they would accept the machines. To this day, no positive information on the new die material has leaked out, so far as I am aware.

The peculiar reciprocity of the Soviet Government in the patent situation may be cited also. Our Patent Office library in Washington has not received full Russian patent specifications issued in recent years; all it has are brief abstracts of these specifications. On the other hand, anyone here may secure full copies of our own patent specifications at a nominal fee and no questions asked.

As far as is known to me, there has been no considerable expansion in the Russian metallurgical literature within the past two or three years, such as has taken place in other countries — for instance, Ger-

(Continued on p. 376)



SURFACE COMBUSTION FURNACE
plus
ElectroniK
CONTROL
equals
"EXTRA-VALUE"
INTERNATIONAL
TRUCKS

Russian Journals for Metallurgy

(Starts on p. 331)

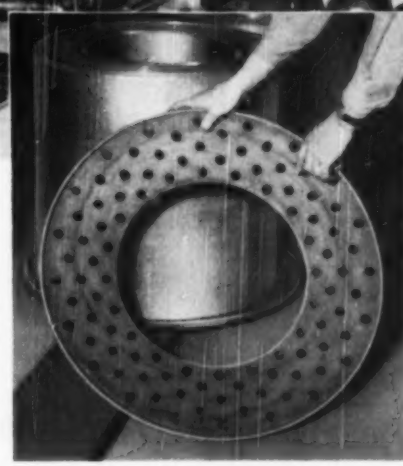
many, England, Australia, Spain and Brazil. However, the quality of the papers, which ten years ago still was quite spotty, has improved. Statements of an author that are not supported by factual data, and shortcomings in experimental procedure, are now in for a reprimand, in the form of an editor's note.

The acquisition of Russian journals — so far as they are obtainable — has been simplified. There is only one channel: The Four-Continent Book Corp., 38 West 58th St., New York 19, whose most recent list of available periodicals carries 208 items, including numerous propaganda mediums (The Hooter, Culture and Life, Soviet Sport, Soviet Art, Labor, Problems of History, The Peasant Woman, The Young Bolshevik, Crocodile). It also carries an "Important Notice!" listing 22 journals that are "oversubscribed and not available for 1950". Sad to relate, "Factory Laboratory" and "Journal of Technical Physics" were placed in the oversubscribed category about the time *Metal Progress* was running its June issue with Russian abstracts from those two journals.

And what will happen if you try to break through the iron curtain to secure technical literature directly from individuals? Here is my story: About three years ago, the address of one Comrade X, research engineer at an Institute in the Urals region appeared in the Letters to the Editor column of an American weekly. Comrade X seemed eager for foreign literature and hence a good candidate to exchange journals with, so I suggested trade to him and actually received a postcard expressing his interest in the proposal and promising to look into the possibilities of obtaining back issues of certain journals for me. Then, after a few months, I was asked, not by Comrade X, but by a Detroit firm, would I kindly pay them the sum of $27.50 covering a book on spectrographic analysis plus five standard samples to go with it, so that they could forward the book and samples to Comrade X. In the meantime, I had received from Comrade X three copies (one of them useless) of a

(Continued on p. 378)

Scovill's New Continuous Strip Mill Called "The Most Modernly Equipped"



With various production facilities that rank as the world's largest, the new brass strip mill of Scovill Manufacturing Co. at Waterbury, Conn., is also recognized as "the most modernly equipped".

Pressed Steel Co. light-weight heat-treating trays were chosen to convey the 2,000 lb. coils through the two brass annealing furnaces, also the world's largest. Pictured here, these PSC trays are seamless-formed of Inconel, are ¼" thick, 28¾" in diameter, and weigh 32 lbs. each. Under direct fire, 32,500 lbs. of coiled sheet are annealed per hour.

Pressed Steel Co. offers you the benefit of 20 years experience in designing heat-treating equipment. Alloy seamless formed or welded, in any size or design: annealing and carburizing boxes, covers, baskets, racks, tubes, retorts, etc. We fabricate the complete list of alloys, permitting you to choose the metal that is "alloy right" for your needs. Send blue prints or write as to your needs.

PSC EQUIPMENT IS "ALLOY RIGHT"

THE PRESSED STEEL COMPANY
of WILKES-BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

☆ ☆ ☆ OFFICES IN PRINCIPAL CITIES ☆ ☆ ☆

Russian Journals for Metallurgy

(Starts on p. 331)

journal I wanted, so I sent the money. After that, silence descended and there was no answer to my pleas that three badly soiled magazine copies were really less than I had expected to get for $27.50! I do not know if Comrade X is to blame — probably he is not, because regulations were just then issued governing relations between Russians and non-Russians, and possibly Comrade X did not want to be transferred from his comfortable post in Sverdlovsk to less cheerful surroundings in Siberia.

I shall conclude this commentary with an evaluation of the position of Russian metallurgical literature when compared with that of other countries. Thirteen years ago, Dr. R. F. Mehl of Carnegie Tech made a careful survey of the number of research articles in the metallurgical field which had appeared in practically all the scientific literature of the world in the preceding two years.* In compiling the number of articles from the various countries, he found that the quantities produced had the following relation:

Germany	7
United States	4
England	2
Russia	2
France	1
Japan	1

He added that if *quality* of the articles were considered, the United States would be unlikely to improve its position.

If someone were asked to repeat this performance for today's metallurgical literature, he might arrive at the following numbers:

United States	7
England	3
Germany	3
Russia	?

Any such comparisons are apt to be challenged and I will gladly bow to challenges based on actual count. There is no doubt, however, that in the 1937 evaluation, Russia would have received a better rating if the Russian journals had been more fully and adequately abstracted at that time. Today, we simply do not know. The iron curtain is drawn too tight.

*National Resources Committee, 1937, paper on Technical Trends and National Policy, p. 364.

COLD-HEADING DIE STEEL

for *maximum production*

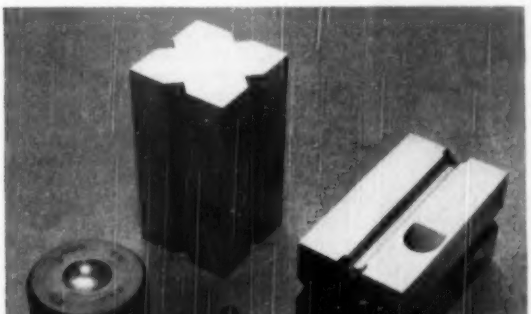
BETHLEHEM XX COLD-HEADING DIE STEEL is more than a match for the most punishing cold-heading jobs. It's the finest steel of its type, having been developed just for cold-heading dies.

It's a special grade of carbon tool steel, having a carbon content of 0.90 to 1.00 pct. Long years of intensive development work were required to arrive at the ideal carbon range, depth of hardness, and grain size which give best service for various sizes of header dies. We recommend a shallow-hardening grade for header dies up to 2-in. diameter; for larger dies a deep-hardening steel has proven most suitable.

This special-purpose steel has controlled hardenability, and every bar represents the ultimate in cleanliness and freedom from flaws. Rigid controls govern every phase of its careful manufacture and inspection. But the real test is the way it meets cold-heading requirements: a hard working surface with good wear-resistance, reinforced by a tough core . . . case-hardness deep enough to prevent sinking or upsetting . . . tough enough to absorb heavy pounding without chipping or spalling.

Large users of cold-heading steel give Bethlehem XX Cold-Heading Die Steel their unqualified approval. And we use this grade ourselves in large quantities in Bethlehem manufacturing operations. You can count on it for maximum production at lowest cost. Our metallurgists will gladly work with you in arranging for a trial in your plant.

Bethlehem Cold-Heading Die Steel gives maximum die life in the cold-heading of steel rivets. At left is the header die; at right, the solid die.



These gripper and header dies of Bethlehem Cold-Heading Die Steel provide the ideal combination of hard working surfaces and tough core for the cold-heading of bolts.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

Bethlehem ULTRASONIC TESTED **Tool Steel**

Metallurgy of Zirconium*

CERTAIN RARE (and even commercial) metals have hitherto been available only in conditions where they possess extreme fragility. This brittleness has turned metallurgists away from any projects to use them commercially in massive form. Examples are titanium, zirconium and chromium. The Northwestern Station of the U. S. Bureau of Mines, located at Albany, Oregon, has for years given much attention to this and other problems connected with the rare metals, under general direction of W. J. Kroll, now consultant to the Bureau.

Brittleness in the purest electrolytic chromium is attributed to the presence of about 1% chromic oxide. Samples of such chromium are heated in a current of hydrogen that is purified and circulated by a zirconium "pump" whose principle is as follows: Hydrogen reacts with zirconium to form a hydride which yields very pure hydrogen when heated. Two batches of zirconium hydride, alternately heated and cooled in a closed system provided with mercury valves, maintain a flow of pure hydrogen over a sample of chromium metal. The zirconium also acts as a "getter" and permanently removes gaseous impurities from the system, including minute concentrations of water vapor formed by reduction of chromic oxide.

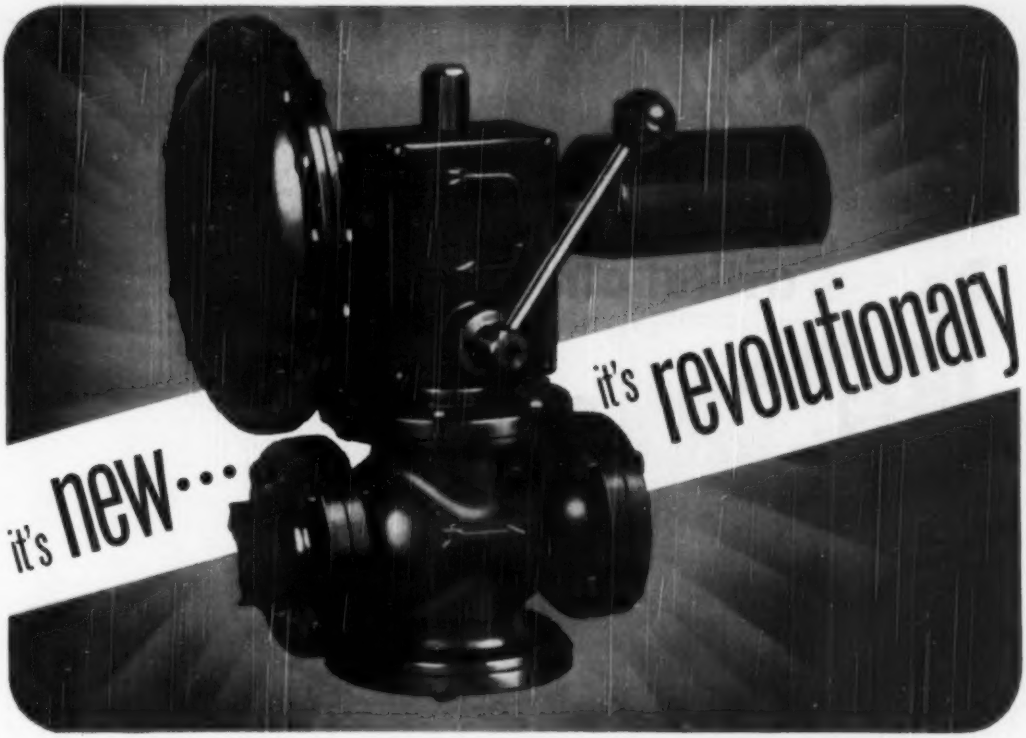
Ductile zirconium is also a highly desirable material, not only for its good mechanical properties and corrosion resistance, but also because it captures neutrons with reluctance. These properties make it especially interesting to the designer of nuclear (atomic) engines.

Zirconium metal is hard and brittle if it contains even small amounts of certain impurities, especially nitrogen and oxygen. These gases may be introduced at elevated temperature during a reduction process or when the metal is heated to form ingots or fabricated shapes.

Zirconium and its sister metal titanium are more abundant than lead, zinc or copper, and they occur

(Continued on p. 382)

*Extracts from "Research Activities of the Bureau of Mines in the Northwestern States", by H. A. Doerner, a paper read before the Engineering Research Council of the Society for Engineering Education, June 19, 1950.



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Zirconium

(Starts on p. 380)

concentrated in easily worked mineral deposits. But the preparation of ductile and workable zirconium or titanium is so difficult that these metals were laboratory curiosities until recently when large amounts have been made at relatively low cost. The zirconium process is carried out in six steps:

Reduction of Zr Metal

1. Zirconium carbide is prepared by heating zircon sand in an arc furnace, wherein the silicon component is vaporized as silicon monoxide. (If purified zirconium oxide is available, the carbide can be prepared more efficiently in a new type of graphite resistor furnace.)

2. The carbide is reacted in a shaft furnace with chlorine gas at 925° F. (500° C.) to form zirconium tetrachloride vapor, which is collected in a condenser attached to the top of the furnace.

3. Crude zirconium chloride is sublimed at 660° F. (350° C.) in a retort filled with hydrogen. Iron and other impurities are left in a small residue and a dense white deposit of purified chloride is collected on cooling coils attached to a removable lid.

4. The lid with its load of zirconium chloride is placed over a pot of molten magnesium metal inside a heated retort filled with helium. As the purified salt is vaporized it reacts with the magnesium to form sponge zirconium in a matrix of magnesium chloride.

5. The reaction pot is supported upside down in an evacuated retort and heated to 1700° F. (925° C.) for 10 hr. Magnesium chloride and residual magnesium metal fuse and drain from the zirconium. Distillation completes this separation.

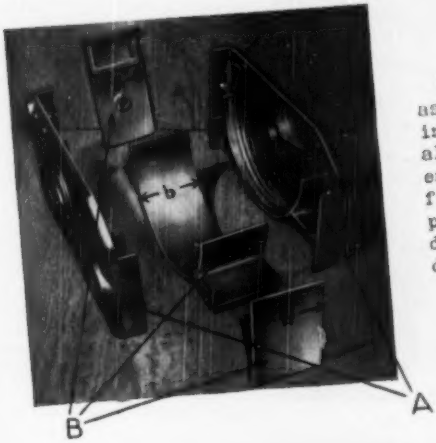
6. Zirconium metal sponge is sorted, cleaned, briquetted, and melted in a vacuum or an inert atmosphere.

Special equipment and techniques required to carry out these steps were developed at the Bureau of Mines over a period of years, first in small laboratory equipment and then in a pilot plant with an output of one 60-lb. batch per week. The station at Albany is now making about 500 lb. of zirconium per week in much

(Continued on p. 384)

Ideas on Welded Design—For the Engineer's Notebook

Design of a coolant separator, made of aluminum, called for production in four different sizes. But what was the secret of making these at high rates and at low costs? Answer — good design, followed by welding. And here is how the job was done:



Only the width was changed as the size of the separator increased, instead of enlarging all dimensions. Identical end pieces, marked "A" were used for all models. Only the center pieces, marked "B," were cast in different widths, with the one dimension, "b," changed.

Next, the cast sections were assembled by HELIARC welding — ideal for aluminum. Here, the HELIARC HW-4 torch is doing the job.

Usual problems of producing complicated castings were eliminated by the design of simple castings and the joining of these parts by HELIARC welding. Rejections were minimized. Result — four different models at high production rate and at low cost.

For additional information about HELIARC welding and other LINDE methods, and for help in solving your production problems, please call our nearest office.

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Zirconium

(Starts on p. 380)

better equipment. All this metal is used experimentally to test its properties and possible uses, and to develop the very difficult techniques required to cast sound ingots of zirconium and its alloys, and to forge, swage, roll and draw the ingots into plates, sheets, rods, and wire. Since this metal becomes brittle when exposed to air at low red heat, the ingots must be sealed in an iron jacket for hot working into plates or sheets. The pure metal melts at so high a temperature (approximately 3350° F. or 1850° C.) and the melt is so reactive that contamination is almost unavoidable when zirconium is melted and cast.

Zirconium has exceptional resistance to attack by most chemical solutions including strong acids and alkalis at temperatures as high as 100° C. It has satisfactory mechanical properties for structural purposes. These physical properties and resistance to corrosion are affected by the presence of impurities and alloying constituents, and by fabrication and heat treatment procedures.

Binary Alloys of Hydride Titanium*

THIS paper deals with binary alloys of titanium containing 2, 4, 6, 8 and 10% of chromium, cobalt, iron, manganese, molybdenum, nickel and tungsten. Commercial titanium hydride was supplied by Metal Hydrides, Inc., Beverly, Mass. The alloys were produced by normal powder metallurgy techniques (100,000-psi. pressure) without a binding agent. Unsintered compacts were 0.43 x 0.38 x 2.75 in. The mixtures containing Cr, Mo and W were sintered for 5 hr. at 2370° F., those with Fe and up to 8% Co at 2000° F., and those containing Ni and 10% Co at 1830° F.

(Continued on p. 386)

*Abstracted from "A Study of Some Alloys of Titanium, In the Manufacture of Which Commercial Titanium Hydride Powder Was Used", by W. E. Kuhn, H. V. Kinsey and O. W. Ellis, *Transactions*, Canadian Institute of Mining and Metallurgy, Vol. 53, 1950, p. 54-67.

Titanium Alloys

(Starts on p. 384)

Results of flexure tests on duplicate specimens were reasonably consistent, but tensile test data were far from consistent. The high values for transverse strength of the iron alloys are worthy of note (Table I).

Forgeability was tested under a small drop hammer capable of delivering a maximum blow of 530 ft-lb. For the 10% alloys forged at 1650° F., the alloying elements rated in the following order (most easily forgeable given first): W, Ni, Co, Mo, Cr, Mn, Fe. Of these 10% alloys, Ti-Co was about the same as 18-8 stainless steel at the same temperature, and Ti-Fe about the same as Nimonic 80, a nickel-base heat resisting alloy.

In creep tests at 1000° F., W, Mo, Cr and possibly Fe appeared to be the most important elements in their effect on the creep-rupture properties of titanium. The remarkable resistance to deformation in forging exhibited by the 10% Fe alloy at 1650° F. was not reflected in the creep-rupture tests at 1000° F.

Table I — Results of Transverse Flexure Tests on Binary Titanium Alloys
(Higher of values from two tests)

%	Modulus of Rupture, 1000 Psi.						
	Cr	Co	Fe	Mn	Mo	Ni	W
0	75	75	75	75	75	75	75
2	87	144	168	78	73	72	95
4	101	136	197	81	78	72	122
6	100	142	206	110	87	69	103
8	102	134	156	97	104	79	180
10	101	137	87	110	117	77	137

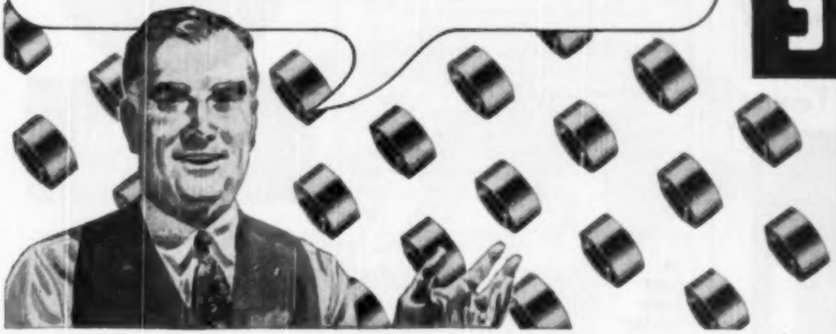
The differences among unalloyed compacts made from seven different lots of titanium hydride were quite marked. For compacts sintered 5 hr. at 2370° F., hardness varied from 388 to 564 Vickers, modulus of rupture from 83,000 to 32,000 psi., and forgeability from 352 to 970 ft-lb. for 50% reduction. This indicates the need for specifications on commercial titanium and titanium compounds. However, the properties that should be restricted by specifications are by no means clear.

Vacuum fusion analyses of samples from various lots of titanium hydride showed hydrogen ranging from 0.0013 to 0.0087%, nitrogen from 0.0085 to 0.1890%, oxygen

(Continued on p. 388)

WE INCREASED PRODUCTION 71% WITH J&L "E" STEEL

J&L STEEL



(a story* about how to win customers and influence prospects)

"Got a minute? Well, let me tell you about what happened at our machine shop a couple of months ago when we first tried that new J&L "E" Steel. You wouldn't believe it was possible! (Confidentially, neither did we until we proved it to ourselves.) Here's what happened.

"We got an order to produce a big lot of plunger stops for solenoid starter switches. They're tricky to run, and you've got to be pretty careful every second. We'd read about "E" Steel in some of J&L's ads, and decided we might try some on this job.

"So we ordered some 17/32" E-33 "E" Steel stock, set up our B&S #2 and B&S #0 Automatics and began to turn out parts. We had used B-1113 for this job before and had been getting 350 pieces per hour. But we soon realized we could machine much faster with "E" Steel, and **we kept increasing speed until we were getting an average of 600 parts per hour. That's a 71% production increase!**

"Next thing we discovered was that our tools were lasting twice as long; and the chips were coming off better with "E" Steel than they did with B-1113. We also found that the finish on the parts had improved from 20% to 25%.

"That's why we've been using "E" Steel. We turn out work much faster and can take on more jobs. Our men like the way "E" Steel machines and our customers get better parts and better service. Everybody benefits!"

Get your copy of the new booklet titled "'E' Steel Evidence." It outlines a series of 22 case histories from machine shops that have used "E" Steel with excellent results. Write for your copy.

** Based on an actual case history.*

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Titanium Alloys

(Starts on p. 384)
from 0.0720 to 0.9240%, and total gases from 0.0925 to 1.1184%.

Oxidation tests in air at 1350° F. showed that, of the alloying elements investigated, only tungsten definitely improves the oxidation resistance (Fig. 1).

Considerable discussion is included concerning the metallography of sintered compacts of titanium and titanium alloys. In particular, efforts were made to correlate the amount of "light-etching matter" with various mechanical properties. The identity of this light-etching matter could not be firmly established. The authors tentatively assumed that it consists of a compound or compounds of titanium oxide, nitride, or both, in solid solution in titanium. However, the analyses for carbon, oxides and gases did not lead to any direct relationship between the amount of light-etching matter in the microstructure and the content of gaseous impurities.

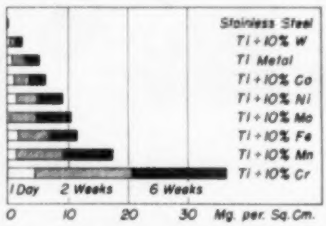

Fig. 1 — Gain in Weight of Binary Titanium Alloys During Oxidation at 1350°F.

Surface Hardening*

SINGLE CRYSTALS of copper, aluminum and iron were surface hardened by burnishing, and the hardened layer was tested for microhardness by continuously increasing the load applied and the depth penetrated until the computed hardness became identical

(Continued on p. 390)

*Abstract from "Correlation Between the Hardness Produced on the Surface of Metals by Mechanical Means and the Depth of Structural Changes", by K. H. Leise, *Metallforschung*, Vol. 2, 1947, p. 111-114.

THE FASTEST MACHINING BAR STEEL ON THE MARKET

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Machined 63% Faster—
Increased Production 58%
Improved the Finish
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LA-LED B-1113

LA-LED Replaces B-1113

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Form tool	S.F.M.	+63%
Drill	S.F.M.	+62%
Threading	S.F.M.	+62%
Feed on Form		+10%
Feed on Drill		+10%
Time/part		−38%
Production/hour		+58%
Steel cost		+12%

HERE'S a typical example of the amazing production increases that are possible when ordinary screw stock is replaced with LA-LED, the *fastest machining steel bar you can buy.*

An oil burner fuel unit manufacturer had been using B-1113 in forming this fuel pump plug. When they substituted LA-LED, machining speeds increased up to 63%, and rejections disappeared—with a resultant increase in production of 58%! Furthermore, finish on the plug was greatly improved, and they estimated tool life to be substantially increased.

LA-LED is an entirely *NEW* steel, with startling super-machinability. However, it offers much more than that. Being an open-hearth steel, it has a much sounder cross section than Bessemer. Its good ductility and surface quality permit bending, crimping and riveting operations impracticable with Bessemer steels. And, LA-LED machines to a fine satiny finish and permits closer finished-part tolerances. LA-LED is available cold-finished—
in rounds, $\frac{5}{16}$" through 3";
in hexagons, $\frac{5}{16}$" through 1½".

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Surface Hardening

(Starts on p. 388)

with that of the still unaffected core of the metal. Next, electron diffraction patterns were taken of the surface and after that the surface was slowly etched away by electrolysis in HCl; then more patterns were taken and the operations repeated until the regular structure of the soft unstrained metal was reached. The author found that a truly "powdered" state of the metal goes to a depth of a few microns only, where the structure changes to a fibered one that passes continuously into ordinary crystalline grains at a depth of not over 70 microns.

Austempering Versus Oil Quenching

(Text is on p. 325 to 329)

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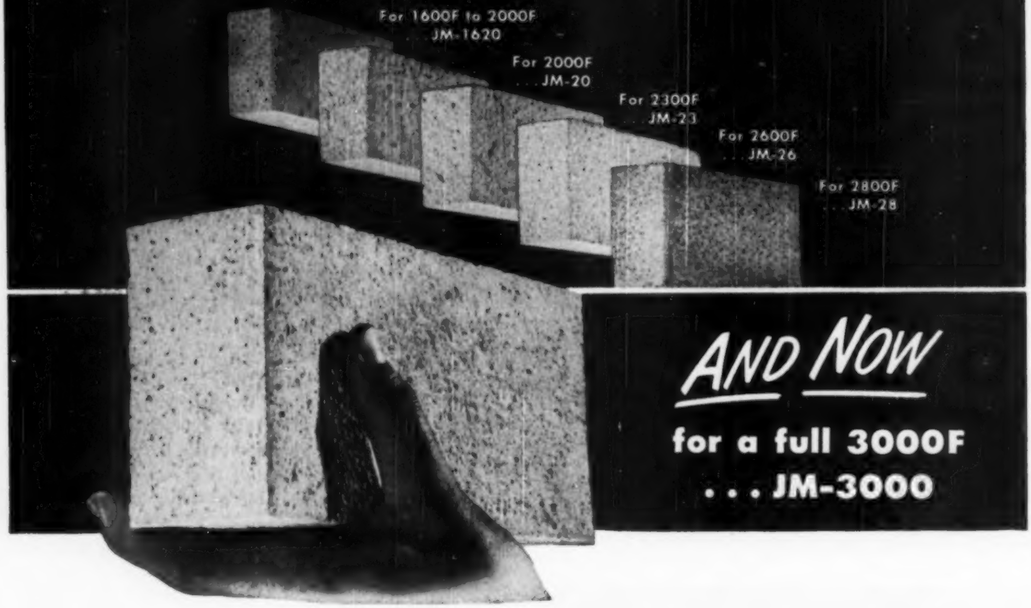

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	JM-1620	JM-20	JM-23	JM-26	JM-28	JM-3000
Densities, lb per cu ft	29	35	42	48	58	63-67
Transverse Strengths, psi	60	80	120	125	120	200
Cold Crushing Strengths, psi	70	115	170	190	150	400
Linear Shrinkage,† percent	0.0 at 2000 F	0.0 at 2000 F	0.3 at 2300 F	1.0 at 2600 F	4.0 at 2800 F	0.8 at 3000 F
Reversible Thermal Expansion, percent	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F
Conductivity* at Mean Temperatures						
500 F	0.77	0.97	1.51	1.92	2.00	3.10
1000 F	1.02	1.22	1.91	2.22	2.50	3.20
1500 F	1.27	1.47	2.31	2.52	3.00	3.35
2000 F	—	1.72	2.70	2.82	3.50	3.60
Recommended Service:						
Back up	2000 F	2000 F	2300 F	2600 F	2800 F	3000 F
Exposed	1600 F	2000 F	2300 F	2600 F	2800 F	3000 F

† 24-hr simulative service panel test for JM-3000; 24-hr soaking period for other brick.

* Conductivity is expressed in Btu in. per sq ft per F per hour at the designated mean temperatures.

Note: Above tests are in accordance with A.S.T.M. tentative standards.

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A Digest of the Production, Properties, and Uses of Steels and Other Metals

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Extra-Low-Carbon STAINLESS STEEL

New Type Chromium-Nickel Steels Have Added Corrosion Resistance

New and improved austenitic stainless steels of the 18-8 type have been developed which have superior corrosion resistance after being exposed to heat. These steels, known as extra-low-carbon stainless steels, were designed especially for use in welded and stress-relieved equipment that is exposed to more severe corrosive conditions than are normally encountered by other types of straight 18-8 stainless steel.

Under severe corrosive conditions, intergranular attack may occur in the higher carbon unstabilized grades of austenitic stainless steels that have been subjected to the temperature range of 800 to 1600 deg. F. during welding or hot forming operations. It is generally agreed that this type of corrosion is caused by complex carbides that are formed at the grain boundaries of the stainless steel during heating.

The effect of heat is rarely harmful in the ordinary fabrication of stainless steel for most applications, such as in architecture, the food and dairy industries, in hospitals, and in the home. However, in the chemical and other allied industries, where stainless steel is used in the handling of very corrosive chemicals, these new extra-low-carbon stainless steels should most certainly find wide use.

Fig. 1 Left: Carbide precipitation at the grain boundaries of an 18-8 stainless steel, containing 0.059 per cent carbon, after being held at 1200 deg. F. for 1 hour. Right: Absence of carbide precipitation in 18-8 stainless steel of 0.03 maximum carbon content, after being held at 1200 deg. F. for the same length of time.

In general, there are three ways in which the precipitation of carbides can be controlled in stainless steel:

1. Heat-treating so that the carbides present are dissolved.
2. Alloying with an element, such as columbium or titanium, that will tie up the carbon in the form of a harmless carbide.
3. Decreasing the carbon content of the steel.

Fig. 2. The new extra-low-carbon stainless steels are especially suited for large types of process equipment, such as this fractionating tower. They require no heat-treatment after welding.

Heat-Treatment After Welding

Before the development of extra-low-carbon stainless steel, or of the "stabilized grades", one means for preventing intergranular corrosion was to heat-treat stainless steel that had been subjected to the dangerous temperature range, so that the precipitated chromium-carbides would go back into solid solution. It was found that when a welded part was heated to temperatures of 1950 to 2000 deg. F., and then cooled rapidly, most of the carbides were retained in solid solution. This extra heat-treatment is sometimes impractical, however, because of the design or massive size of some types of welded equipment.

Use of Columbium and Titanium to "Fix" Carbon

As the result of a search for a method of producing stainless steels that would be immune to intergranular corrosion without heat-treatment, the columbium- and titanium-bearing stainless steels were developed. These elements form carbides more readily than chromium. It was found that columbium, when present in a 10 to 1 ratio to carbon, completely "fixes" the carbon and renders it harmless in stainless steel. A similar effect can be accomplished by alloying with about five times as much titanium as carbon. Steels thus alloyed with columbium or titanium are known as "stabilized grades."

Decreasing Carbon Content

The most recent development in preventing intergranular corrosion has been the extra-low-carbon stainless steels. To be substantially harmless in stainless steel for as-welded or welded and stress relieved chemical equipment operating at temperatures under 700 deg. F., carbon must not be present in quantities over 0.03 per cent.

In 1937, ferrochrome with 0.03 per cent maximum carbon was first produced for the steel industry by ELECTROMET. This product has helped make it possible to produce very-low-carbon stainless steels—steels that are completely immune to intergranular corrosion when welded or subjected to a stress-relieving heat-treatment.

Metallurgical Service Available

If you use welded stainless steel equipment, it will pay you to investigate the advantages of using extra-low-carbon steels. If you produce stainless steel, our metallurgists will be glad to give you technical assistance in the use of ferrochrome of 0.03 per cent maximum carbon. For further information, write to the nearest ELECTROMET office.

For a more detailed account of the properties of extra-low-carbon stainless steel, write for a free copy of the technical paper, "Resistance to Sensitization of Austenitic Chromium-Nickel Steels of 0.03% Max. Carbon Content".

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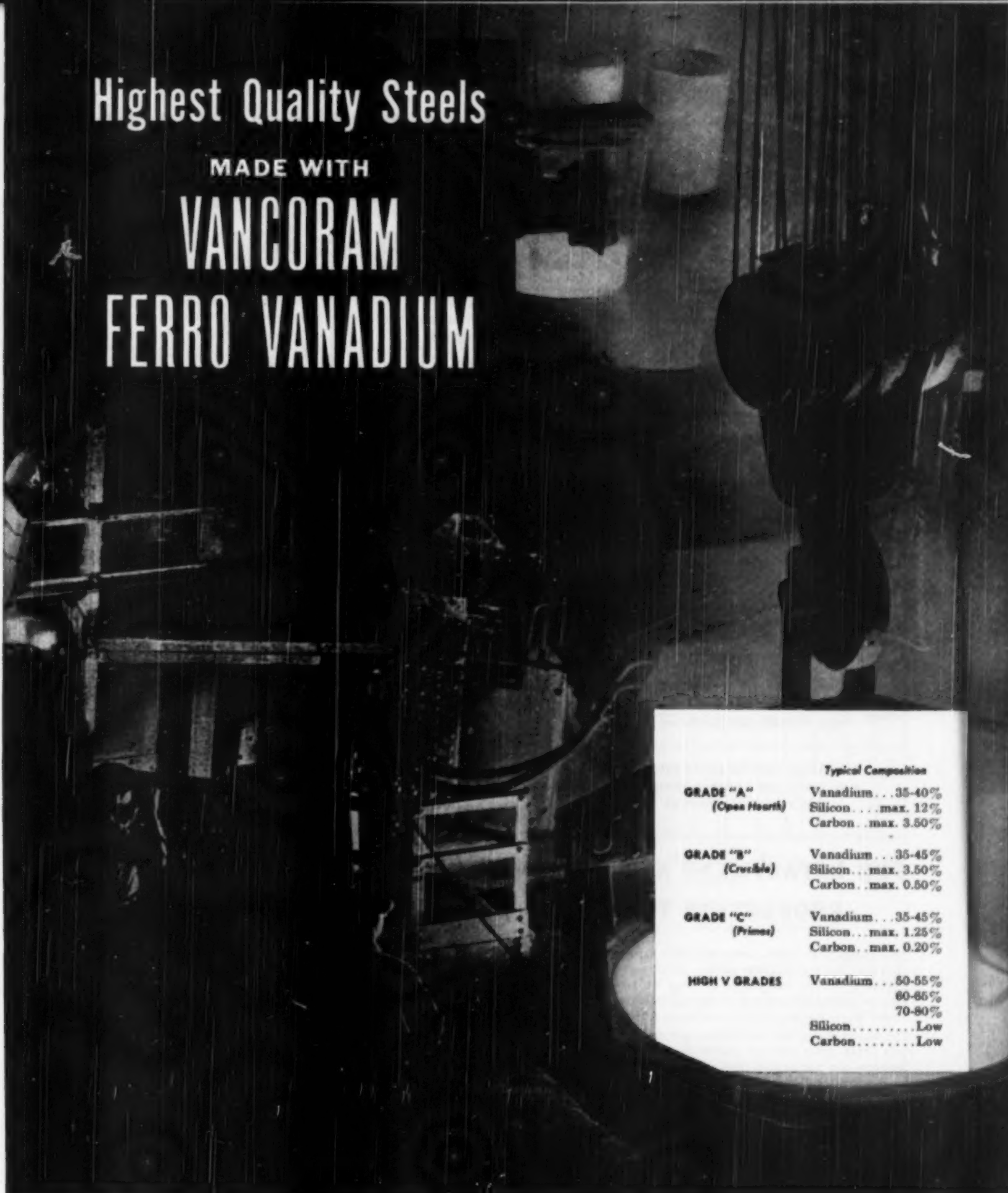

	Typical Composition
GRADE "A" (Open Hearth)	Vanadium . . . 35-40%
	Silicon . . . . max. 12%
	Carbon . . max. 3.50%
GRADE "B" (Crucible)	Vanadium . . . 35-45%
	Silicon . . . max. 3.50%
	Carbon . . max. 0.50%
GRADE "C" (Primos)	Vanadium . . . 35-45%
	Silicon . . . max. 1.25%
	Carbon . . max. 0.20%
HIGH V GRADES	Vanadium . . . 50-55%
	60-65%
	70-80%
	Silicon . . . . Low
	Carbon . . . . Low

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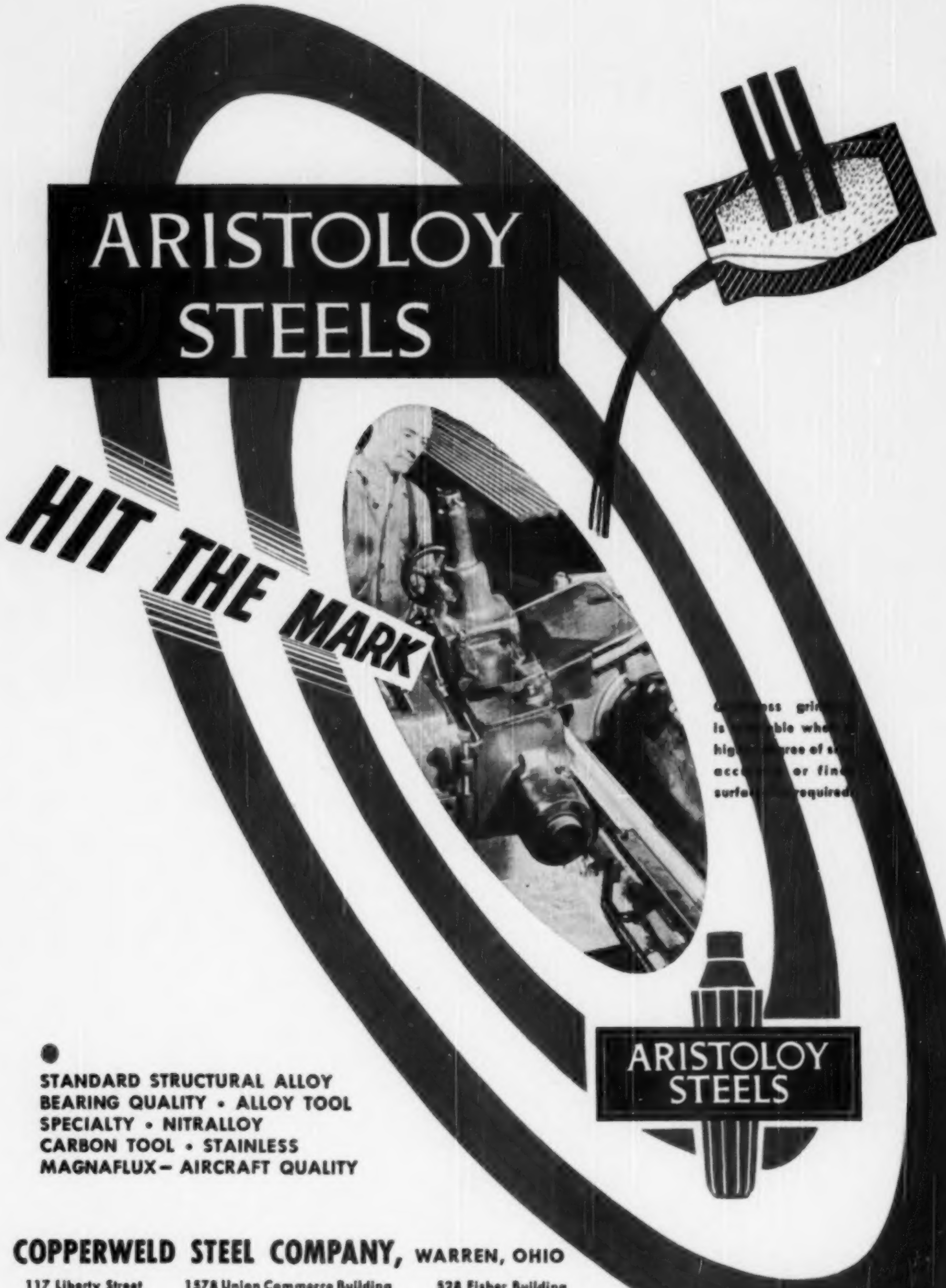
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